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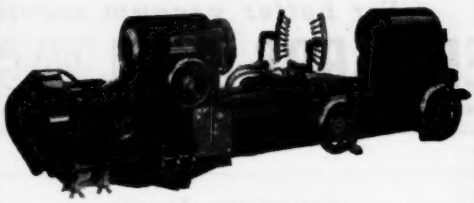

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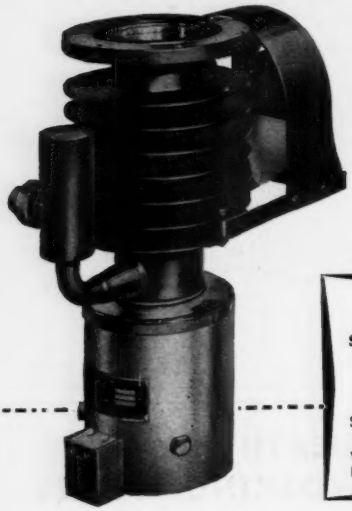

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EDUCATION FOR MANAGEMENT

IT is still less than ten years since the Urwick Committee issued its report on education for management and only nine since the British Institute for Management was established. In that period, however, increasing attention has been given both to the selection of managers and administrators and to the training they should receive and where it is best given. Particular aspects of the broad problem have been discussed in connexion with the Civil Service and its reform, and following a report on education for management by one of the productivity teams which visited the United States in 1951, it has been discussed at conferences arranged by the Federation of British Industries and the universities of Great Britain as well as in connexion with the expansion of university education in general and of technological education in particular. The Fleck Report on the coal industry in Britain emphasized the significance of leadership at the highest level for the efficient running of an industry, and also the importance of the coal industry, or any other industry, taking positive steps to throw up its own leaders, while Sir Eric James's little book "Education for Leadership" had already provoked a wider discussion on the implications of the post-war changes in the educational system of Britain.

There had thus been a good deal of discussion on the selection and training of managers before the recent public concern about automation had stressed the increasing importance of efficient management and the need for even greater care in the selection and training of managers. At the annual general meeting of Unilever Ltd. on May 24, Lord Heyworth devoted a large part of his chairman's address to the importance of good management in industry, the qualities required in a manager to-day and the best means of finding and developing the necessary talent. Emphasizing that merit should be the only test of suitability for managerial rank, and that no particular social or educational background is demanded, Lord Heyworth described briefly the methods of selection adopted by Unilever Ltd. For the scheme run in Great Britain, about half the successful candidates come from inside the firm, and of the external candidates most of them have had a university education; and Unilever's experience in the United Kingdom is that a degree in any field can form an adequate background and provide suitable mental training for the general side of business, though there are many posts for which a technological education is essential.

Lord Heyworth remarked that the attitude of the universities to industry, as well as that of industry to the universities, is changing, and that the traditional resistance to the employment of graduates is fast disappearing, while the universities are increasingly ready to co-operate with industry. He also said that the most important training of the potential manager is done individually and on the job, and that it must be flexible and selective. There is no general scheme, and unless the right men are sent on the right courses, there can be a waste of time and even positive harm. For more senior managers the firm uses the opportunities provided by such institutions as the Administrative Staff College at Henley, and the advanced courses available at places such as the Harvard School of Business Administration, and he stressed the value of meeting in this way people from completely different fields of business, from the Civil Service and the nationalized industries. Industry, he remarked, should ensure that it sends students of high quality, and it can also help by seconding first-class men to assist on the instructional side; and if universities are to develop the teaching of business administration, he favoured the experiment of seconding the university teacher to industry for a year or two to gain an inside view of how industry works.

While the fullest use should be made of conferences and similar techniques for keeping a manager's mind supple and alert, it is also essential to delegate real responsibility. Special care, too, is necessary to avoid the dangers of inbreeding; but it is necessary to strike a mean, although more interchange between one business and another at senior levels has its merits in spite of practical difficulties. Unilever itself possesses an advantage in that the international diversity of its business enables it to widen the experience of many managers by postings to countries outside Britain. Such postings, and also promotions, are the work of 'placement committees', responsible for watching the progress of promising men and selecting and recommending the right man for the right vacancy. On the whole, this has proved the most satisfactory method; but methods of recruitment and selection and training require continuous examination.

Lord Heyworth's observations are the more interesting in the light of the report on "Management Succession" which was issued almost simultaneously by the Acton Society Trust*. In earlier reports the Acton Society Trust has already examined problems of training and promotion generally in nationalized industries. The present report is limited to the recruitment, selection, training and promotion of managers. It is not a manual of such methods, but represents the results of an examination of the policies and practices used for securing a succession of managers by more than fifty very large organizations, and attempts to set forth the lessons that can be learnt from their experience.

The general aim of the investigation, which was sponsored by the Joint Committee on Human Relations in Industry of the Department of Scientific Research and the Medical Research Council, and financed from Counterpart Funds derived from

* Management Succession: The Recruitment, Selection, Training and Promotion of Managers. Pp. vii+139. (London: Acton Society Trust, 1956.) 10s. 6d.

United States Economic Aid, was to gain knowledge which might assist management both in the larger and also in smaller companies, where many of the problems are similar. First, it analyses the educational background and careers of existing managers, and particularly attempts to discover what opportunities existed in the past for promotion from the shop floor. Next, it reviews the problems encountered in recruiting, selecting, training and promoting these managers and the methods used for solving them, while finally the attitude of employees to the promotion policies of a few selected companies are summarized.

This report accordingly is a contribution to the solution of one of the key questions in industry to-day—that of ensuring an adequate supply of managers of high calibre; and one of its most startling findings is that one-third of the very large companies the practices of which were studied are making no systematic efforts to secure such a succession. Of the 3,327 managers whose background was studied, more than half began as manual or clerical workers and went only to an elementary or an ordinary secondary school. One in five went to a public school, more than one in four to a grammar school and only one in five has a degree, and less than one in five a professional qualification. Nevertheless, the analysis of the background of the younger managers suggests that the successors to present managers will be better educated and more qualified and that, as might be expected from the wider educational opportunities, the proportion rising from the bottom will decrease.

It is the next two or three chapters that are of particular interest to the scientist. An analysis of the background of present managers with the view of discovering which factors are most advantageous from the point of view of promotion indicates that arts degrees, and especially when taken at Oxford or Cambridge, are far more advantageous than science degrees, and technical qualifications come well below a science degree. Non-technical professional qualifications appear to be more advantageous, however, ranking well above a science degree and even above an arts degree except one obtained at Oxford and Cambridge. Men from major public schools seem to have done well whether they possess a degree or not; but the results of this study raise the questions whether different criteria are applied in selecting arts graduates and graduates in science or applied science, and whether the latter class of graduates are given adequate chance to show if they have qualities justifying promotion to the highest managerial posts. It should be noted, however, that the staff of research departments were not included in the sample; and at the other end the disadvantage under which men holding the position of foreman suffer suggests the question whether they are given a fair chance of training and selection for promotion.

These are questions which demand consideration not only within industry but also in planning the expansion of technological education and to some extent the development of university courses, particularly postgraduate, since there is evidence that higher degrees in any university or faculty are much more advantageous than science degrees, though less so than first degrees in arts. The greater educational opportunities and the higher standard required for management have clearly made most companies look to the universities to supply more of their future managers. It is true, as Lord Heyworth points out, that training for management must be given largely within industry, even if industry does not require the assistance of the universities and colleges of technology in giving such training; but the universities will be in a better position to supply industry with the type of graduate it desires if industry co-operates more closely and indicates clearly the qualities it is looking for in the graduates it seeks.

Conferences arranged by the Federation of British Industries have already done something in this direction; but this study by the Acton Society Trust directs attention to one aspect of the present search for talent that is particularly serious in the existing man-power situation. Competition is intense for the more able recruits, and few companies can get all they wish; yet there are great differences in the wastage of graduates between different companies. For graduates in science and applied science, these have varied in the past five years from 6 per cent to 63 per cent, and the average of 29 per cent for twelve companies is too high to be regarded with indifference. For arts graduates the average is 32 per cent; and it appears that many companies have much to learn about the selection, introduction and training of graduates; they do not seem to be aware of the principle that scarce material must be used with forethought and economy.

The elimination of such preventable wastage is one means of reducing the shortage of talent; but few companies have paid sufficient attention to locating talent and developing it in their own organizations. The experience of companies which have paid considerable attention to this problem suggests that, in the absence of an active policy, many who are suitable for promotion will be overlooked. In a large organization it is impossible for the directorate to be aware of all its potential talent, nor is it safe to rely on the judgment of a man's immediate superior, even if he is made aware of his responsibility for looking for promising younger men.

The search for talent is neither easy nor without difficulties, some of which appear very clearly in the chapter in this report which discusses the effect of promotion policies on staff generally. The exact method adopted is, however, less important than the way in which it is used and the spirit behind it; and it is clear from this report that if British industry paid more attention to the subject, to the inequalities of opportunity which exist in different departments and to the problems of introducing and training graduates, and took more care with fundamental training and planned experience which really broadened the individual through varied experience and intellectual stimulus, there might be less need to complain of shortage of talent. Ambitious young men, both during their initial training and even more when it is finished, and before they are given

real responsibility, must inevitably feel frustration from time to time, and attempts to meet this difficulty would help to reduce the wastage and might well contribute to the elimination of some of the absurdities into which the present severe competition for talent has led recruitment. Moreover, there are the intangible factors, such as the climate of opinion.

The study shows beyond question that the shortage of good managers, particularly at the top, is both more noticeable and more noticed than in the past. This is due partly to the greater demands made on management by the need to make the best possible use of limited resources in a setting of full employment; partly to the growing complexity of management, which necessitates a high standard; and partly to greater specialization, which makes it more difficult to produce general managers and has restricted the number of people suitable for a particular job. Automation, which is scarcely mentioned in the report, has made it even less likely that the right kind of manager will turn up spontaneously when required, and may well have increased the importance of those scientific and technical qualifications which at present seem to rank low as qualifications for promotion. Unless, in fact, industry gives much more attention to the planning of management succession and to the identification and training of potential managers at an early age, the shortage of managers is likely to become even more acute, and with increasing educational opportunities such early selection will become more and more important; managers will be drawn increasingly from a more highly selected group than in the past—from rather more restricted backgrounds with higher educational qualifications.

There is no one answer to the problems of management succession and development; but what matters above all is the attitude of mind which is brought to bear upon them. If a firm is to attract and retain able people, it must be apparent that able employees can get on and will not be overlooked, that managers themselves recognize management development as an important part of their responsibilities and that unexpected as well as expected managerial vacancies can be filled without difficulty with really well-qualified people from within. This is only possible if management at the top makes it manifest that it is really aware of and interested in such problems, and seeks to foster the all-important favourable climate of opinion.

Nor is all this a matter of concern to industry alone. The recent discussions on the introduction of automation have shown how closely efficient management touches on social and economic welfare. It is not merely that all grades of management will need fuller knowledge of the technical factors that influence their decisions. Good management can do much to soften the impact of technological innovation on labour and even directly on society; and while the prime responsibility rests on industry, the education policy of Britain could well be shaped to increase the probability that industry's intake at all levels will be equipped as fully as possible to seize the opportunities which industry puts in the way of its personnel. Nor should it be forgotten that the nation's interests, as well as those of industry itself, demand vision and enterprise as well as technical competence in its leaders, and that educational and economic policy contribute largely to the formation of the conditions and climate of opinion which favour enterprise and imagination.

These are all factors to be heeded in considering the expansion of technological education, the universities' plans for the next quinquennium, and economic and social policy in general, as well as the measures industry—as individual units or in concert and in co-operation with the universities—could take to secure a reasonable succession of managers of the highest quality.

PEACEFUL USES OF ATOMIC ENERGY

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy

Held in Geneva, 8 August–20 August, 1955. Vol. 8: Production Technology of the Materials Used for Nuclear Energy. Pp. ix+627. Vol. 9: Reactor Technology and Chemical Processing. Pp. x+771. (New York: United Nations; London: H.M. Stationery Office, 1956.) 10 dollars; 70*s.*; 43 Swiss francs each vol.

THESE are two volumes which must be read by all the chemists, physicists, and metallurgists working on nuclear reactors, for they contain a vast amount of information on the fissile and fertile fuels, on the moderators graphite and heavy water, and on the canning materials such as beryllium, zirconium, steels, and aluminium. Many of the articles are exhaustive treatises on special subjects.

The importance of Vol. 9 cannot be over-estimated; it reports the sessions devoted to the metallurgy of thorium, uranium and plutonium, the fabrication of fuel elements, such as the stainless-steel liquid-metal bonded slugs used in the sodium-graphite and breeder reactors, and the dispersion-type elements as used in the materials testing reactor and in the 'swimming-pool' reactors. The use of liquid metals, and the corrosion they cause, is extensively reported almost for the first time, the chemical processing of irradiated fuels occupies a score of papers, and finally the storage and disposal of wastes are reported. The review of wastes with which the volume opens ought to have been grouped with Session 23*B* on wastes at the end of the volume.

It is unfortunate for the reactor metallurgist that fission occurs primarily in uranium, for no more obtuse metal could have been found! Fig. 30 of Foote's review paper on the physical metallurgy of uranium well illustrates this: a two-inch rod of uranium produced by swaging a cast bar elongates six times its original length merely as the result of cycling 3,000 times between 50° C. and 600° C. The first problem then is to ensure random orientation and fine grain-size; attainment of high purity and alloying can help this, and alloying can impart increased strength to withstand the internal forces created by the substitution of two atoms of fission products for one of uranium. Chiswick and Kelman's paper (557) and Pfeil's (416) report this subject

extensively. Thorium, several times more plentiful than uranium, has a simple cubic crystal structure and so exhibits no such changes on thermal cycling. Carlson's very long paper on the metallurgy of thorium is exhaustive, dealing with many of the alloys in great detail and referring to the precautions to be taken in fabricating and machining this element and its alloys.

Plutonium is almost an unknown quantity metallurgically; it is a pity that there is no paper on the fabrication of the fuel elements for the breeder reactors in this volume; but the intermetallic compounds are described in paper 826.

Uranium is canned in aluminium tubes in several reactors, and we are indebted to Kiessling of Sweden for a good description of the solid-state reactions between uranium and aluminium over a wide temperature range, although we need a supplementary account of the effects of radiation on the boundary layers between these elements. Anodic coating of the inside of the aluminium can, or the provision of an aluminium silicon layer, delays interdiffusion up to 300° C. For higher-temperature operation the oxide of uranium has been considered in a short paper (559), and Howe reports (paper 825) the zirconium-clad rods for use up to 800° C. (or possibly 1400° C. for thorium–uranium systems), and the liquid metal (NaK) bonded rods in stainless steel for the breeder reactor. For lower-temperature reactors, especially the water-moderated reactors, and research reactors, uranium has been dispersed as UAl_4 throughout an aluminium mass afterwards clad in sheet aluminium to retain the fission products (papers 561 and 953 report fully on the materials testing reactor fuel elements).

The liquid metal technology holds great hopes for the future; the liquid sodium (or NaK) cooling is essential for fast breeder reactors, while reactors employing the liquid bismuth–uranium, bismuth–thorium mixtures would—if successful—avoid the refabrication of fuel elements. There has been a lot of experience gained with Na (or NaK) over many years—it came as a surprise to me to learn that valves on all American aero-engines and on many American cars are cooled with liquid sodium. Paper 123 recounts General Electric experience on the first breeder reactor, and the problems of the important sodium-graphite reactor are fully described by North American Aviation. The liquid bismuth fuel breeder reactor is still being studied as a possibility, and paper 118 is exceptionally interesting in the descriptions of the use of titanium and zirconium as inhibitors in reactions between uranium and graphite and uranium and steel at the temperatures around 500–700° C. It is interesting to note that early use of inhibitors was developed by the General Electric of America for mercury boilers. Again, information is needed as to whether these inhibitors are equally successful in the presence of neutron flux, and metal loop tests threading through reactors are necessary.

In the Chemical Session 20, the Westinghouse paper (537) deals with the important problem of corrosion in the water-moderated power reactors operating at high temperature and shows the effectiveness of the 'Zircalloy-2', a zirconium–tin alloy, in reducing the effects of corrosion; apparently there is no complete solution in sight. Another way of avoiding chemical digestion and refabrication of fuel elements is to purify the fuel in molten metallic form by liquid metal solvent extraction—using an element such as silver which dissolves plutonium and many fission fragments, but is not dissolved by uranium. Voigt fully describes this in paper 592.

For the reactor metallurgist the interest of Vol. 8 lies in the records of Sessions 16 and 17, which dealt with the moderators and some constructional materials of reactors. There are massive papers from the United States on heavy water, graphite, zirconium and beryllium, supported by others dealing with special points of purification or analysis. This is another volume which shows the tremendous extent to which America contributed to the success of Geneva by disclosing so much secret work; but the contribution from some small countries such as Portugal and the Argentine are nevertheless important and most welcome.

Benedict surveys (paper 819) the production processes for heavy water; so far heavy water has been a by-product of processes which have borne the main cost of production. These, however, have not been and are not likely to be of a scale large enough for reactors of the future using heavy water as coolant and moderator—needing a charge of, say, 50 tons per 100 MW.; thus the Norsk Hydro Co. in the course of producing a million cubic feet of hydrogen per hour electrolytically for ammonia synthesis produces a mere 2 tons of heavy water per year. When huge quantities are needed, single-purpose processes will be required using water as the primary feed, and four of these processes are analysed in detail. There is need for further developments of catalysts to make these reactions cheap enough to compete with the by-product processes. A paper by Gaunt describes an infra-red absorption method of determining the deuterium content of heavy water, a method which could be applied to continuous monitoring.

The review by Currie *et al.* on graphite (paper 534) is very informative except on chemical analysis of trace elements. One of the major problems is the 15–30 per cent variation of the physical properties of graphite made from different sources of coke by the same processing methods. The Pechiney Co. in France reports similar variations of properties, and another paper from France deals with the estimation of boron in graphite down to a few parts in one million.

The zirconium paper by Shelton *et al.* reviews the early history of the Kroll and iodide processes for the manufacture of metallic zirconium after separation from hafnium. Initially the Kroll sponge was refined by the iodide process; but now after careful control of contaminants ductile metal is made by arc melting the Kroll sponge, and costs only £3 per lb. It is disappointing that in the section on alloys there is no reference to the important 'Zircalloy-2'. The separation of hafnium by the liquid counter-current extraction process is described; the Russian paper describes the recrystallization method of separation developed by Coster and Hevesy. No mention is made of the use of hafnium.

Beryllium production is described in papers from the U.S.S.R. and the U.S.A. The Russian method is the electrolysis of the fused chlorides (beryllium and sodium) followed by distillation of the metal *in vacuo*, and sintering of powder before hot pressing rods and tubes at 600° C.; the American method is the reduction process of the fluoride by magnesium yielding a metal of 99·5 per cent purity. Even after redistillation the metal is no more ductile than less pure samples and the conclusion is reached that,

unlike zirconium, there is little hope that further removal of metallic impurities or oxygen will result in greater ductility. Alloying and the use of oxygen scavenging elements has led nowhere. The cost of the metal has been borne primarily by the beryllium–copper industry; but it is anticipated that the nuclear power industry will now cheapen production. It is interesting to learn that long exposure of the metal in the materials testing reactor (Idaho) caused no significant changes in properties.

The first half of this volume is devoted to the ores of uranium and thorium and the production of the metals, and makes interesting reading to the non-specialist. We learn that the ion-exchange methods are revolutionizing uranium ore processing plants and yield high-grade concentrates directly from the leach liquors. Florida processes ore in the form of phosphate for artificial fertilizer manufacture, so that 100 gm. of uranium per ton results as a by-product. Yugoslavia shales treated for mercury yield 136 gm. of uranium per ton as a by-product. Rich zircon ores of Brazil contain up to 4 per cent uranium. Many of the Witwatersrand ores mined for gold contain uranium (but no quantitative figures are given), and as the cost is borne by gold it is likely that uranium will now be extracted from low-grade ores. The Canadian and South Australian rich ores are mined solely for uranium, and no figures are given for these. The U.S.S.R. tells us nothing.

Thorium content of Brazilian monazite averages 6 per cent and uranium 0·3 per cent; a very far-reaching paper (850) from the United States points out that due to the ionic radii of uranium and thorium these elements are localized in a small fraction of igneous rocks and that a high percentage can be leached from granite without digesting the rock as a whole. This opens up the possibility of extracting millions of tons of uranium; interesting, but will not thermo-nuclear reactions save us from dissolving up the world's granite?

T. E. ALLIBONE

METALLURGY OF ZIRCONIUM

The Metallurgy of Zirconium

Edited by Benjamin Lustman and Frank Kerze, Jr. (National Nuclear Energy Series. Division 7—Vol. 4.) Pp. xviii+776. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 75*s*.

IN 1948 the production of zirconium in the United States was measured in hundreds of pounds: by 1953 it was measured in hundreds of tons. "The Metallurgy of Zirconium" is not only a reference book, but also gives some account of the extremely rapid scientific and technological development over this short period of time. It is an exhaustive treatise, and the editors are to be congratulated for assembling the efforts of more than fifty authors into a coherent whole.

The extraction methods, and in particular the Kroll and iodide large-scale processes, are dealt with in detail. A full chapter devoted to the latter process gives an excellent account of the development of an extraction method from virtually the laboratory scale to the full-scale production plant. This type of information is all too rare in technical literature.

Metals of interest in the field of nuclear energy are characterized by the stability of their oxides, carbides, nitrides, etc. Because of this, difficulties arise in the development of fabrication techniques; neutral heating atmospheres are normally needed, and the choice of container materials for the molten metals is very limited. In the case of zirconium, the development of arc-melting techniques capable of producing 1,000-lb. ingots has circumvented the container problem and is described in detail. Additional small-scale methods for melting are also described—namely, auto-crucible, skull, drip and levitation melting—all of which must be of interest where very reactive metals are concerned. Potential users of zirconium would do well to pay attention to the section of Chapter 6 on the recovery of scrap, which points out the many difficulties associated with reclamation of machine scrap. Powder metallurgy techniques which have proved of great value in the fabrication of beryllium and thorium, and to a lesser extent uranium, appear to be of less use in the case of zirconium but are obviously well developed. Zirconium of high purity is very ductile at room temperatures, and an account is given of a wide range of cold-working operations. Despite the great affinity of zirconium for oxygen at elevated temperatures, hot-working operations can apparently be carried out without the use of protective furnace atmospheres. Pickling in acid is afterwards required to remove the contaminated surface layers.

The chapter on the physical metallurgy of zirconium and its alloys leaves little to be desired, the only physical constant which proved difficult to find being the X-ray density. Partial or complete equilibrium diagrams are given in the appropriate section for thirty-two binary alloy systems, and brief results are given for a further five systems. Engineering data are given at length in the chapter on mechanical properties, and the marked effect of minor amounts of contaminants upon these properties is emphasized. These contaminants have an equally marked effect upon the corrosion behaviour of zirconium, as detailed in Chapter 11. Most of this latter information is made available for the first time, having been previously placed in the category of 'Classified' material. This is also true of a good deal of the information in other chapters, as is stated in the introduction.

It is difficult to find fault with this book. The overall impression it leaves is one of admiration for the technological achievements described; perhaps this feeling is tinged with envy for the scientific resources of the United States, where an effort involving at least fifty senior scientists and technologists, complete with supporting staffs, could be mounted to investigate the metallurgy of just one metal.

J. WILLIAMS

INTRODUCING GEOLOGY

Geology and Ourselves

By F. H. Edmunds. Pp. 256+12 plates. (London: Hutchinson's Scientific and Technical Publications, 1955.) 21*s*. net.

MR. F. H. EDMUNDS in his long experience on the staff of the Geological Survey of Great Britain has met with a lively interest in his science and its economic applications. Accordingly, he has written this introduction for the layman to show the importance of geology in everyday life.

Almost half the book is devoted to a simple general survey of geology. A short account of the early

history of the subject is followed by a neat splitting of modern geology into its four main compartments: physical geology; mineralogy and petrology; palæontology; and historical geology. This is followed by chapters on geological surveys and maps, on the relatively new sciences of geophysics and geochemistry, and finally an interesting short chapter on the methods of drilling boreholes in the ground.

The second half of the book introduces economic geology, and the author is able to draw upon his practical experience in the selection of some suitable British examples. There are chapters on water supply, building materials, engineering geology, coal mining, ores, petroleum geology, and on geology and agriculture. The penultimate chapter refers to a number of other aspects of applied geology, such as the problems of mining subsidence, but concludes strangely with a few paragraphs on early man. A final chapter touches briefly on the possibilities for amateur work in geology.

This book, as the author writes in his preface, is "in no sense a text-book". The second part would justify its inclusion in a school library, but otherwise it is suitable only for the general reader. Such a book, intended for the layman, should be attractively illustrated and interestingly written. Compared with some of the beautifully illustrated popular science works to which we are becoming accustomed, this book makes a poor impression. Of the photographs a few, such as the one of a fissure produced by mining subsidence, are impressive; but others, such as the small aerial view of King George V Dock during construction, are of doubtful value. The diagrams throughout are uninspired, and the writing, though clear, is pedestrian in style.

Errors are few, though Chapter 4, on historical geology, contains several. It is stated, for example, that Great Britain "contains representatives of every one of the geological systems from the Cambrian upwards", while later, under "Miocene System", we find that "there are no Miocene deposits in Great Britain". In the stratigraphical table on pp. 76–77 Oligocene rocks are incorrectly referred to as being restricted to the Isle of Wight. In this table, too, the Devonian rocks are curiously listed stratigraphically as comprising Lower Old Red Sandstone, Marine Devonian, and Upper Old Red Sandstone. Finally, the placing of the Downtonian Series in the Silurian instead of in the Old Red Sandstone is not in accordance with the practice now followed by British workers on these rocks. There are several misprints in page and plate references which could easily have been avoided. The contents list on p. 5 contains two of these incorrect numbers.

C. H. Holland

PROTECTIVE CURRENT TRANSFORMERS

Protective Current Transformers and Circuits

By P. Mathews. (Advanced Engineering Textbooks.) Pp. xv+253+4 plates. (London: Chapman and Hall, Ltd., 1955.) 36*s*. net.

MEMBERS of the staff of the British Thomson-Houston Company are preparing a series of advanced text-books on electrical engineering, and the second book of this series covers the subject of protective current transformers. This is the first book of any standing on this subject and will be welcomed by all concerned with the design and use of protective gear for the wealth of information it contains, supported by the authority of a leading designer. Mr. Mathews does not shirk any of the difficulties of his subject and has written his book for the benefit of workers in this field of engineering. It is scarcely to be considered suitable for engineering students. The title of the book suggests two subjects, but it is clear that the author is mainly interested in transformers: circuits are discussed only in so far as they affect the transformer design. It is perhaps somewhat surprising that the author does not give an introductory chapter surveying the whole field of protection and indicating the function of the transformer in this field, but apparently he assumes his readers to be already well versed in the general subject and he starts immediately on the transformer.

The book is divided into two parts, the first dealing with design for steady-state conditions and the second with design for transient conditions, which are becoming more important with the increasing use of high-speed protection. Each chapter has its own references—a procedure which is preferable to collecting all the references in one block.

The author bases his treatment on the linear theory of current transformation but does not make clear why the vector theory is unsatisfactory. His development of the linear theory is on the whole clear and easy to follow except for some awkward jumps. For example, he introduces ratio error before he has defined ratio and he passes from the general theory of coupled circuits to the theory applicable to single turns only without any clear dividing line. This leads him into a minor error when he states that the leakage inductance of a toroidal secondary winding with respect to a bar primary is zero, a statement which is only true for a single-turn secondary, although it is a close approximation for a single-layer secondary. For multi-layer secondary windings the leakage inductance is negative. It is noteworthy, however, that minor blemishes of this kind only occur in relatively unimportant places, and the author has evidently taken great trouble to develop a sound treatment of the important parts of his subject. The reading of the book is perhaps made a little more difficult by the author's ruthless disregard of the standard symbols of the British Standards Institution. Some sympathy may well be felt for him when he finds himself at variance with this Institution over the irrational definitions of ratio error and the sign conventions for phase angle of transformers adopted by this body; he is on less sound ground when he uses a small 'e' to indicate current, small and capital letters indiscriminately for r.m.s. currents, $\log_e$ instead of ln, and other variations from standard usage. The coining of new words is always an attractive occupation and the author has allowed himself the luxury of creating the word 'decroachment'. Whether others will accept this rather ugly word remains to be seen.

It is inevitable that the minor faults mentioned in this review should appear disproportionately important; but there appear to be no major faults and the treatment of the transient operation of transformers, in particular, is excellent.

It would not be out of place to include a word of praise for the publishers and printers for the attractive lay-out of the book, the pleasing contrast between the type and the paper surface and the very few errors.

A. H. M. Arnold

WORLD POPULATION GROWTH AND ITS REGULATION BY NATURAL MEANS*

By Dr. C. B. GOODHART
University Museum of Zoology, Cambridge

RECENT discussions on the future of humanity have tended to be rather discouraging, and there are plenty of eminent authorities who are prophesying disaster. World population is now multiplying so fast that at the present rate it is bound eventually to outgrow its food supply, however much that can be increased, and then famine and disease will intervene to prevent further population growth, unless indeed the hydrogen bomb provides an effective and relatively humane alternative to more orthodox Malthusian agents. The only solution seems to be the immediate and universal application of a policy of deliberate family limitation, and few are so optimistic as to believe that this is either practicable or likely to be effective in time to save us from the crash.

It is important to remember, however, that population increase is primarily a biological phenomenon and that the arguments of Malthus, though mathematically sound, are based upon the assumption that man has some specific and constant rate of reproduction which will be the same in the future as in the past unless it is artificially altered. This is a biological assumption that remains to be proved, so I wish to consider whether there are any conceivable ways in which it could be falsified by natural, as well as by artificial, means. Predictions in human demography are notoriously uncertain, and Malthus's disregard of possible increases in production proved him wrong during the past century, so we will do well to examine rather carefully any other assumptions upon which his theories rest.

In the first place we must recognize that man has a rather low reproductive rate, compared with most other animals. A woman who has ten children is reckoned highly fertile, and with fifteen she approaches the prodigious, and yet the domestic pig, of comparable size and on much the same diet, produces as many every year. In man, multiple births are rare, women are fecund for only about half their lives, conception may be inhibited during lactation and more or less complete sterility is surprisingly common. These checks on fertility must be the result of natural selection, for if there had been any real overall selective advantage in higher fecundity it could easily have been evolved. Women are well adapted anatomically for nursing twins, and the tendency to have them is certainly inherited, so that their comparative rarity must mean that, owing probably to higher mortality, there can be no real selective advantage in multiple births even though, potentially, they could increase fertility. Is it possible that the mean fecundity of man could be still further lowered by natural selection? If it could be halved during the next few generations that would probably solve our problems. At first sight this seems unlikely since we usually think of evolution as a slow process working through hundreds of generations; but there is an exception to this rule, where populations are already genetically heterogeneous for the characters involved, especially where the heterogeneity, or polymorphism, results from a balance of advantage between opposing genetic factors. Here, any change in selection pressure may alter the balance quite rapidly and lead to large changes in the composition of the population by altering the proportions in it of the two opposing types.

In Great Britain, for example, we are polymorphic for hair colour and texture: dark, fair and red hair, curly and straight, are all common genetically inherited characters, and quite closely related races may have markedly different proportions of the various hair types, which, if they were subjected to selection, would not remain constant from one generation to the next. We are certainly also genetically heterogeneous for factors affecting stature, though here there are many genes involved and there is a graded series of different heights without any clear breaks as are found for the different hair types. The mean stature of the population seems to have increased by an inch or two since the Middle Ages, and this change may well be the result of natural selection if large people are more affected by food shortage and bad conditions of life than are small; improved conditions now allow more of the largest individuals to survive, so that the average height of the population has increased. There is plenty of evidence that man is also genetically heterogeneous for factors affecting fertility, and if the selective value of the different types were altered there would be a similar change in the mean fertility of the population, quite apart from any artificial restriction of family size. To take an extreme example, one type might have a mean family size of 10, and the other of 2 (though actually, as for stature, there will be a whole series of intermediates), so that a race with 90 per cent of the high fecundity type and 10 per cent of the low would have a mean family size of more than 9, while in another, with the proportions reversed, it would be less than 3. If for any reason these proportions were to be changed in the course of time as a result of natural selection the mean fertility would be greatly altered, and if the selection was strong an effect would be shown after only a few generations. In human beings, of course, fertility depends not only on natural fecundity but also on psychological and social factors which may limit the fertility of physiologically fecund individuals; but these other factors, like physiological fecundity, may well be at least partially inherited.

The present rate of increase in the numbers of man is quite exceptional; the population of the world has certainly doubled and may have trebled itself in the last half-dozen generations; but the increases have not been the same in all races and classes of mankind. We rightly pay most attention to the teeming millions of Asia and Africa which are now multiplying at such an extraordinary rate; but during the same period many races have had stable or declining numbers, and some are heading towards extinction. The African Bushmen, Australian Aborigines, Red Indians and Eskimoes should not be forgotten when the present mean rate of world

* Paper read on September 5 before Section D (Zoology) of the British Association meeting at Sheffield.

population increase is extrapolated into the future. A century ago in Western Europe we had as high a rate of natural increase as any race before or since, and yet it has been arrested and even reversed, admittedly partly by artificial means, in four generations, and the same could happen with other races as well.

The selective advantages of fecundity are obvious and they are particularly strong in dense populations living under unhygienic conditions and subject to acute epidemic disease and a high rate of infant mortality. Cholera and plague strike indiscriminately at rich and poor, strong and weak, alike, and where only a fraction of the children born can hope to live to rear families of their own, only the larger families will be represented in the next generation, irrespective of the quality of the individuals concerned, for small families are liable to be wiped out completely. Thus in these dense disease-ridden communities selection for fecundity is relatively stronger than for most other qualities. In primitive races of pastoral nomads or hunters, however, who live widely separated under hygienic conditions, disease may be less important and the principal limiting factors will be periodical shortages of food. Here fecundity loses much of its selective advantage compared with such other qualities as strength and intelligence, and may even become a liability. In a bad year an Eskimo might be able to find enough food to keep one or two children from starving; but if it had to be shared among ten all would be weakened by hunger and die. It is just these primitive nomadic peoples that seem unable to recover their numbers after they have been afflicted with diseases introduced from outside. Individually they are often more virile and fitter in all respects but fecundity, compared with other races living a much less healthy life in dense centres of population, who seem able to replenish themselves almost immediately after the most disastrous epidemics. Yet we must remember that for 99 per cent of his history man has lived as a nomadic hunter and food collector; the densely settled agricultural and urban communities characteristic of the last few millennia are really a very recent development. We cannot, therefore, assume that the high fecundity found in these dense and unhealthy aggregations of population are necessarily typical of the species; it might well have been evolved in response to these rather special conditions, and if selection pressures alter in the future, reproductive rates would alter too and might revert to the lower levels characteristic of our remote nomadic ancestors which would be more 'typical' of the species as a whole. Improvements in medicine, which would allow more children to reach maturity and so lessen the risk of extinction of lower fecundity lines, would diminish the relative advantage of high fecundity, which will have been disproportionately increased when man, at the dawn of history, abandoned his former more healthy nomadic way of life.

However, it is notorious that declining numbers are found not only in primitive peoples brought into contact with civilization, but also in many of the most advanced nations and classes, whose declining numbers certainly cannot be attributed to genetical selection by famine. It has been suggested that the conditions produced by civilization and a high standard of living may in themselves be unfavourable to fertility, and it is certainly true that the more or less stable population in north-western Europe at the present time owes much to the introduction of artificial methods of family limitation which are only practicable in relatively advanced and prosperous communities. However, the universal rule of declining numbers in advanced civilizations dates back long before the discovery of artificial means of bringing it about, and we must not overlook the possibility that those qualities leading to success in man may have become genetically correlated with relatively low fecundity, and there are some *a priori* arguments in support of such a view.

Under most conditions high fecundity has a clear selective advantage in itself quite apart from any other qualities with which it may be associated, but the less fecund lines will not survive unless they have other hereditary qualities of high survival value to offset the selective disadvantage of low fertility. It is obvious that a man with a dozen children, however ill-favoured, has a better chance of leaving grandchildren, as unpleasing but as fecund as their parents, than his neighbour with one plain daughter; but an exceptionally good-looking and intelligent young woman has little difficulty in finding a husband, even though she may lack brothers and sisters. Brains and beauty, virtue and sex-appeal, wealth and social position—that does not exhaust the list of attributes that may influence a man in the choice of his bride, before he considers her capacity to present him with a dozen children.

Francis Galton once showed that, in the British peerage, wealth in women was correlated with infertility. An heiress by definition comes of an infertile family, for otherwise there would be many to share her wealth, and many noble families have become extinct through the love of heiresses whose riches were matched by their infertility. We may now put forward another rule, that not only wealth but also nubility in women is likely to be associated with infecundity. Attractive girls will usually marry, and the fecund will have large families while the less fecund will do their best and will certainly leave some descendants in future generations. Unattractive but highly fecund girls will be less likely to marry; but those that do will have plenty of children so that, as a group, the unattractive but fecund will also leave descendants. However, the group that is both unattractive and infecund will be at a double disadvantage and so will tend to be under-represented in future generations. Consequently in each generation, owing to the elimination of this last group, we would expect to find that the mean fertility of nubile and attractive mothers should be below that of the less attractive. This proposition cannot easily be proved. There seems to have been a regrettable lack of research on nubility in women; but as an illustration of what is meant we may consider the breeding record of King Louis XV of France and Mme. de Pompadour, the subject of a recent biography by Miss Nancy Mitford. The King took as his wife the Princess Maria Leczinska of Poland, aged about sixteen and probably deliberately selected for dynastic reasons on account of the splendid record of fertility in her family. She developed into a plain, healthy and rather dull woman who enjoyed the King's not undivided attentions until, at the age of twenty-seven, her reproductive career ended with ten children of whom six survived to maturity. Mme. de Pompadour then took over the far from nominal duties of *maîtresse en titre*, which she performed to general satisfaction for nearly twenty years. She was aged twenty-three when she met the King and had had

one child who died young; but though she is said very much to have wanted children by the King, and had several miscarriages, she had no further living children; the King himself left plenty of evidence elsewhere of his own continued fecundity. Mme. de Pompadour, who was considered one of the most attractive, intelligent and accomplished women of her time, came of a bourgeois family that had risen in the world to a position of considerable affluence, and her own mother, married at an early age and renowned more for her beauty than her virtue, herself had only two children. The contrast in fertility between the nubile mistress and the unattractive Queen is striking.

Using similar arguments we would expect that most other human characteristics leading to success in life will become genetically associated with lower fecundity, quite apart from the fact that in more advanced communities low fertility in itself usually results in a higher standard of living.

We know that in animals and plants genetic characters are usually only maintained at the highest level if they are subject to continuous selection, and that there is a loss of fitness as soon as selection pressure is relaxed; this process has been called 'genetical erosion' by Prof. S. C. Harland. There is probably an example of this effect in man with milk yield. A considerable number of civilized women are unable to feed their own babies, although in more primitive races mothers seldom have this difficulty, so long as they are adequately fed. The easier life of civilized women is unlikely to be the direct cause of their inability to produce sufficient milk; but, since artificial feeding is now perfectly satisfactory, selection against low milk yield has ceased. In less advanced peoples, on the other hand, the only children to survive infancy are those whose mothers did have an adequate milk flow. In domestic cows milk yield has been greatly increased in a few generations by deliberate selection, and in civilized man the reverse seems to have happened, also in quite a short time, as soon as selection was relaxed. So also, if selection for the highest fecundity is relaxed, we would expect to find a fall in the average fecundity of the population, as is in fact seen in advanced races with low mortality.

I have suggested that, in man, the more desirable qualities are likely to become genetically associated with lower fecundity, and that there is good evidence that man is genetically heterogeneous for factors affecting fertility. It is likely that this heterogeneity will be maintained by a balance of advantage between higher fecundity on one hand and other qualities of high survival value associated with lower fecundity on the other. It is indeed hard to see how the observed heterogeneity could exist at all unless there was this compensating factor, for without it the lines of lower fecundity could never survive in the face of natural selection. Any equilibrium of this type will be an unstable one, and will be disturbed if the mortality-rate in early life is altered; if it is lowered the *relative* advantage of high fecundity will be diminished, and so we would expect the lower fertility lines to show a proportionate increase.

All this, of course, is rather speculative, and since experiments are impossible really conclusive evidence one way or the other is very difficult to obtain. It may, however, be instructive to consider the population problems of Ireland, which do suggest that selection against fecundity may have had important results over quite a short period. Before 1750 the native Irish lived in conditions of the direst poverty, and must have had a high infant mortality with correspondingly strong selection in favour of fecundity. The introduction of the potato then raised the standard of living, and there was an extraordinary increase in the population, similar to, but greater than, that occurring at the same time in England and elsewhere. In Ireland, however, the increased population supported itself almost exclusively on this one food crop until in the 1840's, in the words of H. G. Wells, "the weary potato gave way under its burden" and was blighted by disease, with the inevitable result of a disastrous famine followed by disease and emigration. In the normal course the formerly highly fertile population should have replenished itself rapidly and resumed its growth with only a slight check; but this did not happen, and the population of Ireland has continued to decline until now it is barely half of what it was in 1840, though most neighbouring countries have doubled their populations during the same period. A probable explanation of this unexpected decline is that since the famine there has been rather strong selection against large families, though artificial restriction of numbers has probably been less important in Ireland than elsewhere.

In the first place, large families are likely to have been worse affected by the famine than smaller ones; where there were numerous children to share the little food available all would be weakened by starvation and may have died. Secondly, and even more important, emigration will have been selective. An only son who has hopes of inheriting the family farm, however impoverished, will not readily abandon it; but if it is to be shared among half a dozen brothers, most of them will be inclined to seek their fortunes elsewhere when times are bad. By 1850 the population of Ireland would have lost most of its more fecund members, leaving the task of replacement to the genetically less fecund who remained. For various special reasons this process is likely to have been continued. A girl's chances of marriage depended largely on the size of her dowry, and that was inversely proportional to the number of sisters who had to share what could be spared. The peasant economy required that adult children should remain on the family farm as unpaid workers, and this tended to advance the age of marriage and so to reduce the number of children born. That in itself was an important, though not a genetical, factor in limiting population; but it is also likely that the more enterprising and virile young men and the more highly sexed girls will have rebelled against these restrictions and left for abroad. The present low fertility in Ireland seems to be due largely to late marriage and failure to marry rather than to low fertility in those women who do marry young, and it is said that many people in Ireland nowadays are 'not the marrying type'. Their infecundity may be psychological rather than physiological, but it is none the less real, and psychological characteristics can be inherited just like anything else; their preponderance in the population could well be the result of selective emigration of those that *were* 'the marrying type'. This process, once started, will continue, for a girl who wishes to marry but lives among a lot of confirmed bachelors will be all the more likely to try her luck elsewhere. Although economic impediments may be given as the reason for late marriages, they are unlikely to be its primary cause, for a much lower standard of life than that at

present enjoyed in Ireland does not prevent marriage and procreation in many other countries, and it was not effective in Ireland before the emigrations. Nor is the influence of the Church to be neglected, the call to the convent or the priesthood will no doubt be all the stronger if there is little in the way of worldly wealth to be left behind, and it would not be surprising to find that the mean number of brothers and sisters to each priest and nun in Ireland was significantly higher than for married people of the same age-groups.

There is another important argument in favour of our suggestion that the selective disadvantage of lower fecundity is compensated by other characters of high survival value associated with it, and that is in the inheritance of intelligence. It is well known that in Great Britain at the present time really large families of ten or so children are often of low quality and below average in intelligence, and it has been suggested that since the less intelligent seem to be the most prolific this means that the average level of intelligence of the population will be falling, and that 'civilization is rotting at the core'. In point of fact the only really large-scale direct observations that have been made, on the intelligence quotient of school children in Scotland in 1932 compared with 1947, failed to show any sign at all of the expected fall in mean intelligence. This has been considered a very puzzling and unexpected result; but it is puzzling only on the assumption that the fact that the largest families are to be found among less-intelligent people means that as a group the less intelligent will leave proportionately more descendants in each generation. This is by no means self evident for, quite apart from possible higher mortality in large families of low quality, the data refer only to the low intelligence of the largest families but give no information about the mean family size of the less intelligent as a group. If intelligent people (though fewer of them have really large families) more often marry and have small families than do the less intelligent, they may well leave as a group as many descendants as the less intelligent, of whom a few have the largest families but a higher proportion leave no children at all. If this really is what happens, the mean level of intelligence of the population should remain constant and the Scottish results are puzzling no longer.

We might be able to get direct evidence of differential survival in high- and low-fertility lines in populations for which statistics are available of the distribution of family size two or three generations back. From these we could derive a figure for the number of great-grandchildren to be expected by women who had families of various different sizes, which could be compared with the number of maternal great-aunts and -uncles actually possessed by a sample of children from the latest generation. If they were below the expected number this would confirm our hypothesis that relative infertility a few generations back had been compensated for by better survival and reproduction among the descendants of the infertile families.

To sum up, we have suggested that human populations are genetically heterogeneous, or polymorphic, for factors affecting fertility, and that this heterogeneity is maintained by a balance of selective advantage of high fecundity on one hand and other factors of high survival value associated with lower fertility, on the other. These other factors are seen to be mainly such qualities as intelligence and nubility, which by increasing the chances of success in life and of marriage should compensate for lower fertility, with the further possibility that better health and lower mortality may also be involved. In addition, the lower fertility lines may have a larger proportion of small families with fewer individuals leaving no children at all, so that the difference in mean fertility will be less than is suggested by a consideration only of the largest families in each group. An objection may be raised here, that there is little reliable evidence of this hypothetical association of desirable qualities with lower fecundity, and that to outweigh the very real disadvantage of low fertility the association should be too obvious to be overlooked. To this I would reply by asking another question. We know that more or less complete sterility is surprisingly common, affecting perhaps 10 per cent of married couples, besides those people who never intend to marry and who must be considered psychologically infecund. Such infecundity is generally intrinsic and not due to injury or disease, and it is therefore likely to be at least partly conditioned by inherited congenital factors. Since selection against infecundity is absolute, and stronger than for many rare and harmful though not actually lethal genes, how could any genes responsible for it possibly occur at anything like their present level in the population unless the lines that tend to produce infecund individuals had some important compensating advantage as compared with other lines in which the incidence of infecundity was lower?

If this genetic heterogeneity is maintained, as I have suggested, by a balance of advantage between high and low fecundity, the balance will be an unstable one, and the lines of high fecundity but otherwise of lower quality will be especially favoured in dense populations where mortality from disease is high and indiscriminate, and where small families may be entirely wiped out by disease before benefiting from their presumed greater intelligence or nubility. Such conditions have been experienced by man only during the past few thousand years, so that in many parts of the world at present the mean fecundity of the population is likely to be disproportionately high, compared with our more remote ancestors who lived a healthier life in which strength, and intelligence, rather than mere fecundity, had a higher survival value. Now that disease is being mastered and early mortality is becoming negligible, even though we continue to live in dense communities, families of lower fertility but otherwise of good quality will survive so that they can take full advantage of these better qualities in competition, and the balance of advantage should shift away from the lines of highest fecundity but otherwise of lower quality. It is to be expected, therefore, that at first when new medical techniques are introduced into formerly disease-ridden and fecund populations there should be a rapid rise in numbers; but as the less fecund lines begin to benefit from the new situation, and increase, the mean fertility should fall and the population should taper off to a new position of equilibrium at a much higher level of numbers and, perhaps, with a higher level of intelligence and other desirable qualities.

Sir Charles Darwin, in his stimulating and provocative book "The Next Million Years", adopts the Malthusian argument that, in the long run, human population must always be limited by food supplies, and there will always, or at any rate usually, be a large "starving margin", and he concludes with the

challenge that "Anyone who disagrees with my forecast must try to get beyond a vague optimism. . . . In particular he must find a really solid reason which shows how the threat of over-population will be avoided . . . or else he will find that his imagination has gone so far out of the realms of reality that it contradicts the physical or the biological laws of nature".

I have tried to show that there may be, if not really solid reasons, at least plausible arguments not inconsistent with the biological laws of Nature, on the basis of which we may question the fundamental Malthusian assumption that human fecundity has some constant and rather high mean value which could only be altered by artificial means. It is at least conceivably possible that prosperity may provide its own solution to the problem by being the cause of a natural lowering of the rate of increase of the population. Whether my arguments have carried conviction, or whether we continue to believe in the essential correctness of Malthus's analysis, our actions at least will remain the same. No one seriously believes that we can or should deliberately limit increases in world food supplies, nor that we should withhold medical discoveries from over-populated regions, however much many may fear that the benefits they bring will in the end prove illusory. Nor does anyone doubt that these benefits will be the cause of an immediate and, in some parts of the world, at least, an undesirable increase in the present population, which should be restricted by all legitimate means, however much opinions may differ as to what means are legitimate. All I am suggesting is that it is just possible that what we are in any event bound to do may, if we do it in time, not lead our descendants inevitably to disaster.

EFFECTS ON AGRICULTURE OF CHANGES IN THE BALANCE OF NATURE

THE morning session on August 31 of Section M (Agriculture) of the British Association during the Sheffield meeting was devoted to effects on agriculture of changes in the balance of Nature. Mr. E. M. Nicholson, director-general of the Nature Conservancy, opened the session with a paper on "Ecological Research and Farming". He emphasized the common interest of the farmer, forester and nature conservationist in an adequate and well-directed programme of fundamental research into the basic processes of Nature, including soil building, the balance of supply and demand for water, erosion, and the natural control of animal populations. Successful management of Nature, whether for food-growing, timber-growing or conservation, is dependent on a greatly improved knowledge of such processes, which may prove the key to an increase in the rate of formation of natural 'capital' and thus raise the potential 'income' in the form of renewable resources, including vegetation and water. The Nature Conservancy's researches on woodland soils, for example, include studies of the role of different tree species as soil improvers and soil impoverishers, and comparisons of productivity under different species of hardwood trees and conifers compared with weight increases shown by sheep on identical plots scattered within the same experimental area. Other factors being measured include the amount of water used by plantations of trees which would otherwise be available for stream-flow and for water-supply undertakings. It is possible to measure the potential yield of water supply under alternative land uses and to analyse the parts played by, for example, evaporation and transpiration. The Nature Conservancy is now recording potential evapo-transpiration daily in both the east and the north-west Scottish Highlands and in Wales and the Pennines, with results differing considerably from those which had been theoretically predicted.

The maintenance and enhancement of natural 'capital' involve studies now in progress at Moor House Field Station on the management of peat moors and the part played by different types of land management and land use in causing or preventing erosion, which is occurring at a formidable rate, for example, in the Trough of Bowland. Tree stumps and cattle horns of prehistoric age are found even above the 2,000 ft. contour, far above the level at which either exists to-day, and there is little doubt that trees of some sort, if only rowans, alders and willows, could under suitable land management cover some of those areas again, interspersed with improved herbage. In some areas fertility might be raised by making good the chance absence of some soil-improving animal or plant, such as the small hardy strain of wild white clover adapted to high altitudes and heavy rainfalls which has recently been found in North Wales (cf. *Nature*, **176**, 596; 1955).

In discussing the balance of Nature, Mr. Nicholson emphasized that it must be remembered that every natural event, whether or not caused by human interference, opens certain doors and closes others. Civilization, unfortunately, closes many doors permanently by excessive inroads into dwindling residues of so-called waste lands which are the last remaining reservoirs of irreplaceable stocks of genes evolved over millions of years.

Mr. Nicholson criticized popular attitudes towards pest control and quoted results obtained during nearly thirty years showing that the population of the heron in England and Wales has without control measures been effectively held at between 4,000 and 4,700 breeding pairs by ecological limitations. On the other hand, the wood pigeon has been greatly favoured by the systematic killing of its predators, such as sparrowhawks, and by the additional cover provided for breeding in young plantations. Control measures would be extremely difficult in face of these ecological stimuli to expansion. Rabbits became a major pest directly owing to human encouragement, and future rabbit populations will depend mainly on whether we have the will to prevent them, as we can, from returning to former levels.

Nature and its study should be regarded as intimately concerning farmers and foresters, who should aim at understanding and working with Nature, rather than using too many mechanical and chemical short cuts. A moralizing attitude towards our fellow predators on the Earth is out of place, and more understanding should be shown of their important role. As the fine and all-embracing tradition of the great estates has lost its impetus, ecological research may become the basis of a new and equally fruitful outlook, reconciling needs for growing food and

timber with the need to keep the country worth living in for all its creatures, including people.

Dr. I. Thomas, of the Ministry of Agriculture, Fisheries and Food, read a paper on the "Natural and Artificial Control of Vertebrate Pests of Agriculture". He referred to that widely used and dangerous expletive, 'vermin', and gave illustrations of the different categories in which predators must be placed according to whether the point of view is that of growing crops or preserving game. In discussing the economic balance-sheet in Britain for the rabbit, he pointed out that while on the credit side rabbits have been estimated to yield products valued at £15 million annually, probably less than £2 million of this accrued to agriculture. On the debit side, estimated losses before myxomatosis ranged between £45 and £60 million. Rabbit trapping had, especially in its early stages, killed large numbers of predators, including foxes, weasels, stoats and polecats, and some of these predators had been exterminated over certain areas, thus helping greatly to enable the rabbit population to get out of hand. Dr. Thomas gave figures showing that the disappearance of rabbits has not greatly affected either the numbers of foxes or their depredations on livestock.

Dr. Thomas said that where rabbits have been seriously reduced, wood pigeons are now perhaps the farmer's greatest vertebrate pest; yet man has created the conditions for pigeons to multiply. Increased acreages under brassica and pea cultivation have provided much additional attractive food, and it is difficult to protect these crops by methods which are free of risk of killing game such as pheasants. More than 2½ million wood pigeons were reported to have been shot in England and Wales in 1955 and 445,000 during the first quarter of 1956. In this quarter alone, the cartridges probably cost more than £28,000, and 50 per cent of this sum could be claimed in subsidy. Adding this to the agricultural damage (which is very heavy also on, for example, clover leys), wood pigeons are costing Great Britain large sums of money. Dr. Thomas pointed out that while rabbits can be controlled estate by estate, relief from wood pigeon damage requires control over the whole national pigeon population. There is, therefore, little ground for optimism on this problem.

In a paper on "Insect Pest Balance in Agriculture", Mr. A. H. Strickland, of the Plant Pathology Laboratory, Harpenden, Herts, referred to the difficulty of relating the mathematical theories put forward by Lotka, Volterra, Nicholson and Bailey regarding growth and decline of populations to biological data so far available. Proponents of the probabilistic school have suggested, for example, that plagues of a grasshopper *Austroicetes cruciata* would occur in certain favourable areas five or six times in a century, but there is no way yet of forecasting when a plague will occur. Little work has been done so far on natural populations in the field; but ten years ago the National Agricultural Advisory Service Conference of Entomologists started routine assessments of the annual peak population densities of about a dozen insect pests throughout England and Wales, and six years ago the scheme was widened somewhat in scope to include detailed work on population density in relation to economic damage. In 1946 an 'Extensive Survey' was begun of the cabbage aphid (*Brevicoryne brassicae*), based on an annual random sample of about a hundred unsprayed brussels sprout crops throughout Britain. From 1951 this was supplemented by field-plot experiments set up in commercial sprout fields in the main sprout-growing areas. The results to date show that damage by cabbage aphid to brussels sprouts alone is equivalent to 4,500–10,500 acres a year, the average annual financial loss over the past ten years having been £868,000. Organo-phosphorous insecticide spraying, wherever economically justifiable, might have reduced this loss to about £500,000.

Ten years extensive survey has also been made of frit fly (*Oscinella frit*) infestation at harvest, and yield samples are being threshed at Rothamsted for the fifth season. Four experimental treatments have been tested. It appears that, on average in England and Wales, about 3 per cent of oat shoots are killed and about 5 per cent of oat grains are damaged by frost and second-generation larvæ respectively. This implies losses of 1·8 cwt. per acre from shoot destruction and a further 3·5 cwt. per acre from grain damage. The frit flies are thus estimated to cost farmers in England and Wales some £10 million annually. Complete frit control could raise the average national oat yield from 18·6 to about 24 cwt. per acre.

Mr. Strickland emphasized that toxic chemicals are at best palliatives, and are unlikely to provide a permanent solution, which must be sought by changes in agricultural practice leading to conditions less favourable to a high rate of increase of the pest. He cited A. Milne's recent findings that the sheep tick (*Ixodes ricinus*) can be largely controlled by minor alterations in flock management reinforced by re-seeding of old moorland pastures, while the wheat bulb fly *Hylemyia coarctata* can also be affected by suitable rotational and cultural practices. Aphid infestations can be shown to be less severe on fields of five acres than on larger fields, and even drilling a few rows of a cereal at appropriate intervals can mitigate losses from aphids. Finally, Mr. Strickland referred to the recent eradication of the screw worm *Callitroga hominivorax* in Curacao by releasing 16 million pupæ sterilized with gamma rays so that the normal females with whom the sterilized males mated laid sterile eggs. He concluded that further advances in understanding the environmental factors which prevent insect pests from increasing to an unlimited extent depend largely on development of co-operative field-work on the lines recently adopted in Britain.

There was an interesting discussion on a wide variety of topics arising from the papers. Mr. Cook (Ceylon) described difficulties met in coconut research from an even larger pest, the elephant, breaking into seed gardens despite deep trenches, powerful electric fences and other obstructions which were easily circumvented. Noise and the smell of burning rubber tyres appeared the best deterrents. Cattle had been induced to cease eating experimental plants by adding a special food supplement to their normal grazing diet.

Several speakers expressed concern over the problems of reconciling current game preservation patterns with agricultural needs, and asked that the subject should be explored.

This experiment in bridging gaps between the ecological and agricultural approaches was regarded as well worth while, and the convergence of the views expressed from such different angles by the three speakers was remarkable, especially as regards the need for studying pest and other problems from an environmental or ecological point of view, rather than seeking chemical or mechanical magic wands.

SHEFFIELD LABORATORIES OF THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

OPEN DAYS

THE Sheffield laboratories of the British Iron and Steel Research Association are concerned mainly with research on steelmaking, metal working and ferrous metallurgy and are also a base for a section which deals with technical inquiries and investigations on the uses of iron and steel. They form one of the Association's five establishments: research on iron-making, engineering, metal surfaces and coatings, with supporting departments of physics, chemistry and operational research, is done in London, Swansea and Middlesbrough, and the administrative head-quarters are in London.

Open days were held at the Sheffield laboratories during September 6–7, when the opportunity was taken by a large number of visitors to view the work going on there. In the same building, and sharing the Association's general services, are three autonomous co-operative research organizations: the Cutlery Research Council, File Research Council and the Coil Spring Federation Research Organization.

Steelmaking

The Steelmaking Division is concerned with the hot metal when it leaves the blast furnace and until it has been turned into ingots. Current researches deal with the operation of open-hearth furnaces and electric-arc furnaces, the chemistry of steelmaking in each, and the problems of ingots and ingot moulds. Considerable emphasis is placed on the combustion problems of open-hearth furnaces, which produce about 90 per cent of steel in Great Britain. Research in the Association has shown what are the essentials of good burner design, and this knowledge is being widely used in the industry. Sulphur pick-up from the fuel and heat transfer are being studied on a 1/12 scale open-hearth furnace model.

The melting shop at the Association's laboratories houses a 10-cwt. basic electric-arc furnace, which has been used for studying the effects of different power inputs, changing the diameter of the electrodes, the height of the furnace, etc. Other work is concerned with desulphurization and close contact is kept with the more fundamental work on slag-metal reactions in the electric process, which is being carried out in London. The way in which mould dressings work has been observed by high-speed photography through a 'Pyrex' plate let into the side of a mould, and the properties needed in a mould dressing to give a good surface to the ingot have been determined.

During recent years, processes for continuous casting have been developed rapidly, and at least four experimental plants are working in Britain, two of which use a method patented by the Association. Research on the continuous-casting plant at the Sheffield laboratories includes the effects on quality of cooling-rate and of speed and temperature of casting.

Metal Working

The Mechanical Working Division is concerned with forming processes by which the ingot is made into a finished product. The processes comprise rolling, forging, extrusion, wire drawing and sheet metal working. The research also covers the plant and tools of metal working, and the mechanical properties of the products. Among recent and current work, prominence has been given to lines of research of immediate interest to the industry, and some important practical achievements are already claimed.

In rolling, much of the research has been, and is being, devoted to the automatic control of the thickness of strip being rolled. The Association holds several patents in this field, and last year the first industrial installation of its 'setting' method of automatic control of strip gauge was put into operation on a reversing cold-strip mill at the Lancashire and Corby Manufacturing Co. by the Davy and United Engineering Co.; several other installations at home and abroad are in hand. Current research is devoted to the operation of 'tandem' mills used, for example, in the manufacture of tinplate and motor-car bodies; a model three-stand mill has been built for the purpose, with some novel features incorporated.

Investigations of the reheating of ingots and billets for forging have led to significant improvements of present practices in heating. For example, cast ingots of high-speed tool steel can now be heated in an hour or less, as against overnight heating hitherto practised. Among results of recent industrial applications of this are a 25 per cent saving of fuel, a 50 per cent reduction of scale loss, and the elimination of decarburization. Attention is now being given to the mechanization of forging and the improvement of the control of forging plant. The 200-ton laboratory press has been fitted with a position-control system developed by the Association whereby forging is made more speedy and accurate.

In wire drawing, an invention by Prof. D. G. Christopherson of a method for inducing hydrodynamic lubrication has been adapted by the Association to conventional soap-powder lubrication. Full-scale trials in wire mills are more than fulfilling expectations, since dies last twice to ten times as long as previously. In another method, the wire is electroplated during drawing with a thin film of lubricant, which is transparent so as to preserve the high finish required for some applications.

Many other investigations are in progress. The stress–strain characteristics of a dozen steels at high temperatures and rapid rates of deformation have been determined for the calculation of rolling loads in hot rolling. Small steel bars are rolled experimentally as part of investigations into the mechanics of the rolling of sections. The causes of stretcher-strain markings and the mechanisms of their suppression by temper rolling, roller and stretch-levelling have been studied and are now understood more completely. The Swift test of the suitability of sheet metal for drawing and pressing has been further developed. The influence of tool geometry on the mechanical properties of finished forgings has been studied. Experimental investigations have been made of die pressure and drawing force, and of the temperatures in the interior of the die at the interface between the die and wire.

Metallurgy

The Metallurgy (General) Division deals essentially with the treatment, properties and uses of iron and steel. A considerable amount of the work is done extra-murally in university and government laboratories, or collaboratively in the works and laboratories of member firms, but specialist teams in the Divisional Laboratory deal with particular aspects of the work.

Theory suggested that stretcher-strain markings on steel sheet, when deep-drawn or pressed, were produced by the diffusion of nitrogen and carbon through the material. Experiments have confirmed the theory, and have shown that nitrogen has a worse effect than carbon. Transformer laminations are usually made of iron containing 3–4 per cent of silicon. Its magnetic properties are seriously affected by small amounts of impurities, particularly nitrogen. Reducing the nitrogen content of very pure silicon-iron from 0·007 to 0·004 per cent saved rather more than 10 per cent of the total losses, and the effects of additions of nitrogen are much the same in commercial material. The strength, energy and mobility of grain boundaries, which control such properties as brittleness, transformations and recrystallization of metals, are being explored by measurements of internal friction. Work is being done to improve the structure of high-speed tool steels.

Fatigue research was undertaken to determine statistically the variation in fatigue properties of wrought material from different ingots and from different parts of the same ingot for two different casts of steel. Statistically significant variations in properties have been found, but these are not thought to be of practical importance. Further work is in hand with a very-high-tensile steel. Increasing importance is being given to the production, in large quantities, of mild steel having a high resistance to brittle fracture. The effect of variations in rolling conditions, such as variation in the finishing temperatures of rolling, rolling schedules, etc., is being studied.

The analytical section provides a service to the whole Association and also undertakes analytical research. Special methods have often to be developed, for example, for the determination of trace elements, or when only very small samples are available. The characteristics of spectrographic source units and the sensitivity and reproducibility of analysis under various arc-like and spark-line conditions have been studied for a large number of elements normally present in steels.

Steel Users

The Steel Users Section of the Association is mainly responsible for answering technical inquiries on the uses of steel, undertaking *ad hoc* and short-term investigations concerning uses of steel and maintaining contact with the smaller member firms of the Association. Typical work concerns the establishment of the optimum heat-treatment procedure for the manufacture of specific products, investigations of obscure difficulties, and advice on matching the performance of components with steel specifications.

Associated Research Councils

The Cutlery Research Council is an autonomous and independently financed co-operative research organization formed in 1951 to work for members of the Sheffield Cutlery Manufacturers' Association. Its work is organized and controlled by the cutlery industry, but its staff are in close and constant collaboration with the British Iron and Steel Research Association, which provides services, background information on steels, and general assistance. At present the main research projects of the Council are: to improve methods for the production of blanks; to study cutting edges; and to study the grinding and polishing processes used in finishing cutlery. There is also a technical inquiry service, which gives confidential technical assistance to individual manufacturers on application.

The File Research Council is another autonomous and independently financed co-operative research organization formed in 1955 to work for members of either the File Trade Association or the File Manufacturers' Association. The unit is controlled by its member firms, but there is close collaboration with the British Iron and Steel Research Association, which provides services, background information on steel and general assistance. In addition to confidential technical inquiry facilities the Council has begun work on the metallurgy of file steels with particular reference to methods of heat treatment and on testing methods for both saw and engineers' files. The shapes of file teeth and methods of producing a desired shape are also being studied.

The Coil Spring Federation Research Organization has only recently taken over laboratory space at Sheffield; it is in the process of being equipped and expects to undertake active research work in the near future.

OBITUARIES

Prof. Walther Kossel

Walther Kossel, who died after a long illness on May 22, was one of Germany's outstanding physicists, both as a theorist and as an experimenter. He was born on January 4, 1888, into a family that included many men distinguished for their learning. In particular, his father, Albrecht Kossel, was a famous physiologist, long professor at Heidelberg. A students' torch-light procession in his honour, on the occasion of his being awarded the Nobel Prize in Physiology and Medicine, was one of the events during the time when Walther was working for his doctorate in Lenard's laboratory at Heidelberg.

After taking his doctorate in 1911, Kossel moved to Munich, where the University and Technische Hochschule numbered many names renowned in the physical sciences: men such as Arnold Sommerfeld, Max von Laue and Jonathan Zenneck, as well as the world-famous Röntgen. In this stimulating atmosphere he produced work of prime importance on the electronic structure of the nuclear atom, which was then in active development. In particular he dealt with the theory of X-ray emission and absorption, explaining for the first time the mechanism of excitation of the different series and the fine structure of the absorption edges in terms of the Bohr atom. Equally

important was his work on valency and molecular structure in terms of complete electron groups, work which was fundamental for later developments. Together with Sommerfeld he put forward in 1919 the so-called displacement rule for optical spectra. Thus by the time he was in his early thirties, Kossel was known for basic discoveries in quite different fields of atomic theory. At the same time he learnt with Zenneck the latest developments of high-frequency electric waves and took part, during the First World War, in the development of electronic valves.

In 1921 he went as professor of theoretical physics to Kiel, which had a fine tradition, Lenard and Dieterici having held chairs there. Here he continued his work on valency and published a second edition of his "Valenzkräfte und Röntgenspektren", the title of which summarizes his work so far. In 1927 he gave evidence of his devotion to a new subject in his first work on crystal growth, in which he dealt with simple structures only, but in a way that lies at the basis of much recent work. In 1932 he followed his old Heidelberg friend Ramsauer by being appointed to a chair at the Technische Hochschule at Danzig, this time as professor of experimental physics, evidence of the range of his activities. Among his most important work here was the discovery of the interference effects produced by the characteristic Röntgen rays excited in a single crystal, in the first case a copper single crystal, the so-called Kossel effect, first announced in 1935. He also carried out distinguished research on the interference of electrons. The significance of his work was recognized by the award of the Max Planck Medal in 1944.

At the end of the War in 1945, Kossel escaped with his family from Danzig, leaving practically all his possessions there, and started again. After a troubled time he was in 1947 appointed professor at Tübingen, the charming town in Württemberg which had escaped undamaged from the war. Here he had an excellent laboratory and a most agreeable residence in the Physics Institute. A great variety of work was here accomplished under his inspiring guidance. Results were produced in the field of the diffraction of electrons and of light, electrical discharges in gases and in the subject of crystal structure, for which he made use of large spherical single crystals of metal, of the kind first produced by his old Heidelberg friend Wilhelm Hausser.

In 1953 his life was saddened by the loss of his beloved wife, who had shared all his troubles with never-failing courage and gaiety and who was always ready for work or play, as occasion demanded. He was already suffering from the illness that ultimately caused his death, so that his last years were in many ways clouded. But he was mentally clear and active until the end, and his plans for future work showed his old powers. He lectured by special invitation in Paris, for example, in 1955.

Kossel was a physicist whose work was throughout marked by clarity and imagination. The fundamental concepts for theory or experiment were simple and original, and they were carried out with remarkable thoroughness and closeness of reasoning. He was an excellent exponent and devised striking lecture experiments. Personally he was a man of great uprightness and warm affection, whose public life and family life were alike admirable. His loss will be widely deplored.

E. N. DA C. ANDRADE

Dr. E. M. Lourie

CHEMOTHERAPY and tropical medicine have suffered loss by the sudden death on August 11 at Geneva of Dr. Emanuel Mannie Lourie, chief of the Section of Biological Standardization of the World Health Organization. He was born in Johannesburg on February 18, 1904, and studied medicine at University College Hospital, London, qualifying M.B., B.S. in 1928. He took the D.T.M. & H. of the London School of Hygiene and Tropical Medicine in 1930 and the D.P.H. in 1934; and he was elected M.R.C.P. in 1948. After qualifying he worked for various periods in Palestine, at the Liverpool School of Tropical Medicine and at Chicago with Prof. W. H. Taliaferro. In 1934 he returned to the Liverpool School as a Beit Memorial Fellow to work in close association with Prof. Warrington Yorke on the chemotherapy of trypanosomiasis. After the death of Yorke in 1943 Lourie was appointed as the first director of the Department of Chemotherapy of the Liverpool School of Tropical Medicine. During his whole association with the School he was one of its chief scientific ornaments, and in 1945 he was awarded the Chalmers Gold Medal of the Royal Society of Tropical Medicine and Hygiene. In 1948 he left the Liverpool School and after a short period in the Department of Pharmacology at Oxford he joined the World Health Organization, in which his work and his personality were highly appreciated.

Lourie's scientific work covered a wide field; but his main contributions were made in the chemotherapy of tropical infections. In the four years before the Second World War, he and Warrington Yorke discovered the diamidine compounds as a cure for trypanosomiasis and other infections. One of these compounds, pentamidine, was later found to have a prolonged prophylactic action, so that a single intramuscular injection is sufficient to protect against trypanosomiasis for more than six months. This compound has been used prophylactically on a wide scale in Africa and has made a large contribution to the conquest of human sleeping sickness there. Lourie took a major part in developing these compounds, both in Britain and in Africa. In 1943 he discovered that the new antibacterial agent, penicillin, was also very effective in curing mice infected with *Spirochaeta recurrentis*, the organism of relapsing fever. This finding obviously suggested that penicillin would probably be effective also against the organism causing syphilis, and Lourie in collaboration with others showed that this was in fact the case. His important discovery was, however, overshadowed by the simultaneous publications of American workers, and so it did not receive the recognition which was its due.

After the War Lourie showed that the newly discovered antimalarial compound proguanil ('Paludrine') would induce drug-resistance in the malaria parasite of chickens, *P. gallinaceum*. He also studied the melaminyl series of arsenical compounds and promoted the further investigation of these compounds in the field in Africa.

One of Lourie's later contributions to knowledge has only recently been properly appreciated. In 1950 he showed that the acidic compound, suramin, formed complexes with the basic compound pentamidine, such that the toxic action of the two was diminished but the prophylactic action against trypanosomes was greatly prolonged. Recently

Williamson and other workers of the West African Institute for Trypanosomiasis Research have extended this principle to other antitrypanosome compounds, for example, ethidium; compounds of this type will probably be very valuable in controlling the trypanosomiasis of cattle and in opening up for grazing large areas of Africa infested with tsetse flies.

In character Lourie was modest, quiet and reserved; he was a persistent and careful worker and showed great generosity to his junior scientific colleagues. He leaves a wife and one son. His loss will be felt by many friends throughout the world.

F. Hawking

Mr. Llewelyn S. Lloyd

Llewelyn S. Lloyd, who died on August 14, was one of the small band of able Civil Servants Sir Frank Heath brought with him from the Board of Education to help in the foundation in 1916 of the Department of Scientific and Industrial Research. Until his retirement in 1943 Lloyd faithfully served the Department, first as an assistant secretary and later as a principal assistant secretary, and there is no doubt his work contributed very largely to its survival as an efficient organization through the succession of economic blitzes of the years between the Wars. He disarmed the critics by keeping costs low, particularly those of administration, and by encouraging directors to obtain contributions from outside sources towards as many items on their programmes as possible. Though these policies were probably right in the particular circumstances of the time, he was perhaps inclined to carry them too far as the climate for research improved.

Possibly, for one in his position, Lloyd was apt to pay too great attention to administrative details. This, however, made him a most successful trainer of junior staff. To the auxiliary staff he often seemed something of a martinet; but even the most timid registry clerk found, in the end, that his bark was much worse than his bite. Although to his colleagues some of his own letters sometimes appeared too long, his insistence on clear thinking and its expression in forthright English led to his Department achieving a reputation for efficient administration.

The lines Lloyd laid down for dealing with Treasury officials have stood the test of time. "The Treasury," he would say, "can certainly require D.S.I.R. to reduce its demands for money and it must always be satisfied that our estimates are drawn as carefully and closely as possible, but it is not for the Treasury to criticise the scientific aspects of a project or the priority D.S.I.R. attaches to it. These matters have been considered by the Advisory Council whose advice has been accepted by the Lord President."

Lloyd had many interests outside his official work. These included gardening, golf and music. In his later years he was much attracted by the relation between music and science. He embodied his ideas on the subject in a volume entitled "Music and Sound", and spent much time in his retirement in developing them.

Probably few people saw eye to eye with Lloyd all the time; but his was a most endearing personality and those who knew him best count it a privilege to have worked with him. He gave the best years of his life to the Department of Scientific and Industrial Research, which owes him an enduring debt.

O. F. Brown

NEWS and VIEWS

Metallurgical Education in Texas: Prof. E. H. Bucknall

Up to the present, the metallurgical courses offered in the College of Engineering in the University of Texas have been somewhat limited in scope and number, being in the main optional subjects for students in mechanical or chemical engineering. With the recent great influx of industry to Texas and the prospect of intensive developments in the atomic-energy field, an increasing demand is being felt for engineers with a grounding in physical metallurgy, as well as for specialists in this subject. Under the inspiration of Dean W. R. Woolrich, who was for a time scientific attaché at the U.S. Embassy in London, it has been decided to expand the metallurgical content of the undergraduate engineering courses, to institute a master's degree in metallurgy and to sponsor metallurgical research. To carry through this programme, the University has appointed E. H. Bucknall as visiting professor of metallurgical engineering and he will shortly take up his duties at Austin. Prof. Bucknall, who was formerly connected with the National Physical Laboratory and with the Research and Development Laboratories of the Mond Nickel Co., Ltd., has recently returned from India, where he spent three years as director of the National Metallurgical Laboratory and ex-officio director of inspection (metals).

Messrs. Macmillan regret to announce that, as from the issue dated January 5, 1957, the price of *Nature* will be 2s. 6d.

British Iron and Steel Research Association

Mr. C. N. Kington has resigned his post as group manager of the Sheffield Laboratories of the British Iron and Steel Research Association, director of research of the Cutlery Research Council and research superintendent of the File Research Council, on appointment as chief mechanical and electrical engineer of Husband and Co., consulting engineers and architects, of Sheffield, London and Ceylon. Mr. Kington, who is a graduate of the University of Birmingham, received his early training in sound broadcasting and telecommunications. He served throughout the War in the Technical Branch of the Royal Air Force. Dr. J. Pearson, assistant director of the Association, will take charge of the Sheffield Laboratories. At the same time, he will remain head of the Steel-making Division; but he will relinquish control of the Chemistry Department, for which Mr. E. W. Voice, head of the Ironmaking Division, will

become responsible. Mr. R. Mayorcas has been appointed deputy head of the Steelmaking Division. Mr. E. O. Oldfield has been appointed senior research officer of the Cutler Research Council in succession to Mr. Kington; and Dr. J. Pearson has been appointed consultant to the File Research Council, with Mr. R. H. Hancock continuing as senior investigator. Mr. J. G. Wistreich, who has been head of the Metal Working Laboratory in the Sheffield Laboratories, will become head of the Mechanical Working Division in succession to Mr. W. C. F. Hessenberg, deputy director of the Association, who is relinquishing control of the Division in order to devote the whole of his time to his other duties. Mr. S. S. Carlisle, head of the Association's South Wales Laboratories, becomes deputy head of the Division.

Biochemical Principles in Pharmacy

Prof. K. Bullock, in the chairman's address on September 3 to the British Pharmaceutical Conference, discussed "Biochemical Principles in Pharmacy". His survey covers enzymology, chemotherapy and disinfection, the relationship between dehydration and life processes and the architecture of living cells. He has achieved a valuable synopsis which presents a balanced account of important principles relevant to his subject and to hypotheses which appear promising. The historical approach and his sequences of discovery and thought, whereby knowledge has grown, are stimulating—the divergencies from one's own sequences can be intriguing. It is an unavoidable penalty to which even excellent surveys must submit that the illustration of a principle may over-simplify the explanation of cause and effect without consideration of every alternative. For example, the phenomena whereby bacteria can utilize a substrate which at first they could not attack, by enzyme induction, is real enough; but in some instances the phenomena can occur where the enzyme involved is constitutively present but inactive because of coenzyme deficiency. The presence of metal ions—including the monovalent ions—may also affect the activity of some of these enzymes, as the recent symposium of the Biochemical Society shows. Does the reference to the known relationship between the bactericidal properties of the sulphonamides and their antagonism to paraminobenzoic acid exclude other possibilities for sulphonamide action? These comments cannot detract from the value of this extensive and profitable review. When Prof. Bullock dealt with dehydration and life processes, he was in his own chosen field. Does he move almost imperceptively from a position of acquiescence in faith to one of faith in experience?

Engineering Studies in the U.S.S.R.

A British engineering delegation is to visit the U.S.S.R. this month to study engineering education and training. The nine members of the group were nominated by the Joint Committee of the Institutions of Civil, Mechanical and Electrical Engineers and the visit will take place under the auspices of the Soviet Relations Committee of the British Council. A return visit to the United Kingdom by a group of Soviet experts is under consideration. The group will leave London by air on September 16, returning probably on September 28. The programme in the U.S.S.R. will include visits to higher technical education establishments in Moscow and Leningrad. The group will be led by Prof. E. Giffen, professor of civil and mechanical engineering, Queen Mary College, University of London. Other members are: Mr. W. K. Brasher, secretary of the Institution of Electrical Engineers; Dr. B. N. Cole, Department of Mechanical Engineering, University of Birmingham; Mr. H. E. Dance, H.M. Inspector of Schools (Technical Branch); Dr. H. L. Haslegrave, principal of Loughborough College of Technology; Mr. G. S. C. Lucas, director and chief electrical engineer, British Thomson-Houston Co., Ltd., Rugby; Mr. P. E. Sleight, head of the Civil Engineering Department, Brighton Technical College; Mr. E. G. Sterland, principal, Apprentices' School, Bristol Aeroplane Company; Prof. A. S. T. Thomson, Department of Mechanical, Civil and Chemical Engineering, Royal Technical College, Glasgow.

Supply and Training of Teachers for Technical Colleges

A committee, nominated by the chairman of the National Advisory Council on the Training and Supply of Teachers and the chairman of the National Advisory Council on Education for Industry and Commerce, has been set up to advise the Minister of Education urgently upon the recruitment and training of teachers for technical colleges. Its terms of reference are: "To consider in the light of the White Paper on Technical Education (Cmd. 9703) the supply and training of full-time and part-time teachers for technical colleges, and to make recommendations", and it is constituted as follows: Dr. Willis Jackson (*chairman*), director of research and education, Metropolitan-Vickers Electrical Co., Ltd.; Councillor R. McKinnon Wood (*vice-chairman*), London County Council; Dr. F. Briers, principal, Norwich City College and Art School; Sir Hugh Chance, chairman, West Midlands Regional Advisory Council for Technical, Commercial and Art Education; Alderman C. B. Jones, Yorkshire Council for Further Education; Mr. D. R. Mackintosh, Shell Petroleum Co., Ltd.; Miss Anne Shaw, director, The Anne Shaw Organization; Mr. J. G. Docherty, principal, North-Western Polytechnic, London; Mr. A. E. Evans, technical adviser, Association of Teachers in Technical Institutions; Mr. H. Wyn Jones, secretary, Welsh Joint Education Committee; Prof. R. A. C. Oliver, Sarah Fielden professor of education in the University of Manchester; Mr. E. W. Woodhead, Chief Education Officer, Kent; Mr. A. Maclennan, principal, Training College for Technical Teachers, Huddersfield.

Birlec Ltd. Apprentice Training Centre, Birmingham

Birlec Ltd., furnace manufacturers, of Birmingham, have been training apprentices in their works for some considerable time; but in view of the company's plan for expansion and the need to ensure a continuing supply of trained men of the highest calibre, a new apprentice scheme has been launched and a new Apprentice Training Centre has been built specially. Four full-time instructors have been appointed, two of whom have held lecturing posts in the Birmingham College of Technology and the National Foundry College, Wolverhampton, respectively. It is anticipated that the new scheme will cost approximately £20,000 a year. The new Centre is accommodated in single-story buildings and occupies about 10,000 sq. ft. of floor space, with workshop, drawing office and lecture room facilities.

Two main courses are provided, 'technical' and 'craft', each of not less than five years duration. All trainees spend their first year on preliminary courses in the Centre to find the direction in which their abilities lie, and to give them an insight into the fundamentals of engineering with particular reference to those branches with which the Birlec Co. is concerned. After this probationary period, training is then continued in appropriate departments for the remainder of the five-year period, selected apprentices returning to the Centre for advanced instruction at an intermediate stage. All trainees are also required to attend suitable courses at local technical colleges for at least one day a week. Selected apprentices may be offered the opportunity of attending sandwich courses of four to five years at a college of technology, leading to qualification for membership of the appropriate professional engineering institution. There are at present about sixty apprentices in the firm, some forty of whom were recruited this year.

Swiss Society for Natural Sciences

The 136th annual meeting of the Swiss Society for Natural Sciences will be held during September 22–24 at Basle. The opening address by the president, Prof. A. Werthemann of Basle, is on "Pathology of Embryonic Development". Dr. A. Wettstein of Basle will speak on "Aldosteron and Other Suprarenal Hormones", Prof. J. Piveteau of the Sorbonne on "Recent Progress in Human Palæontology in France", and Prof. E. Hadorn of Zurich on "Hereditary Constitution and the Formation of Characteristics". At a joint symposium, the Societies for Medical Biology and for Genetics will discuss "Malformation of the Gonads and Genetic Sex". The Society for the History of Medicine and Science will hold a symposium on "Medicine at Basle in the Baroque Period". A public session of the Swiss Community for Educational and Scientific Research Films will be addressed by Dr. G. Wolf, of Göttingen, and biological and medical films will be shown.

The meeting will be held in fifteen main sections. Foreign contributors include C. E. Tilley (Mineralogy and Petrography) and P. Tschumi (Zoology and Entomology) of Cambridge, and several from the East European Universities of Poznan (Anthropology), Budapest and Greifswald (Chemistry). In the Geophysical, Meteorological and Astronomical Section, Prof. J. Lugeon of Zurich will report on "The World Comparison of Radiosondes at Payern", and on "Measurements of the Electric Potential Gradient and the Conductivity of the Air by Radiosondes", and J. Häfelin and R. Lotmar of Zurich on the "Determination of Weather Effects on Skin Permeability (Experiments on Rabbits)". Prof. H. Hadwiger of Bern speaks in the Mathematical Section on "Selected Problems of Combinatory Geometry in Euclidian and Spherical Space". The Section for Logic and Philosophy lists four prominent speakers, Profs. Paul Bernays of Zurich ("From Syntax to Philosophy of Science"), Emil Walther of Zurich ("The Problem of Direct, Phenomenological Thought"), Felix Fiala of Neuchâtel ("Methodological Notes on Formalism") and François Bonnet of Geneva ("Irreversibility, Disorder and Chance"). The Society announces as the new topic for the one thousand francs Schläfli Prize (open only to candidates of Swiss nationality, closing date April 1, 1959): "Researches on the Distribution of Polyploid Plant Species in Switzerland".

Zoological Nomenclature

As from January 20, 1957, the International Commission on Zoological Nomenclature will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each case, full details of which have already been published (*Bull. Zool. Nom.*, **12**, Pts. 4 and 5; July 20, 1956): (1) *depurator* Linnaeus, 1758 (*Cancer*), interpretation of, by neotype designated for (cl. Crustacea, order Decapoda); (2) *Cherax* (emend. of *Cheraps*) Erichson, 1846, and *Palinurus* (emend. of *Pallinurus*) Weber, 1795, validation (cl. Crustacea, order Decapoda); (3) *ferox* Gmelin, 1771 (*Accipiter*), suppression (cl. Aves); (4) *Maja* Lamarck, 1801, validation of and designation of type species for (cl. Crustacea, order Decapoda); (5) *Sao* Barrande, 1846, and *Ellipsocephalus* (emend. of *Elleipsocephalus*) Zenker, 1833, validation (cl. Crustacea, order Stomatopoda); (6) *Heteralocha* Cabanis, [1851], validation (cl. Aves); (7) *Acrodytes* Fitzinger, 1843, *venulosa* Laurenti, 1768 (*Rana*) and *tibiatrix* Laurenti, 1768 (*Hyla*), suppression (cl. Amphibia, order Salientia); (8) *Palaeophonus* (emend. of *Palaeophoneus*) Lindström and Thorell, 1884, validation (cl. Arachnida); (9) *Actinocrinus gilbertsoni* Phillips, 1836, interpretation of, by neotype (cl. Crinoidea). Comments should be sent as soon as possible to the secretary to the Commission, Francis Hemming, 28 Park Village East, Regent's Park, London, N.W.1.

Museum of Applied Science of Victoria, Melbourne: Report for 1954–55

The annual report of the Museum of Applied Science of Victoria, Melbourne, for the year ended June 30, 1955 (pp. 17; 1956), records major steps in the general building programme which should go a long way to ease congestion. A special exhibit of a demonstration model of the Lurgi plant for the production of gas from the extensive brown-coal deposits in the Latrobe valley has been installed in the main entrance to the Museum. This semi-diagrammatic model was constructed by the staff of the Museum and shows each unit in section, starting with the high-pressure reaction unit and proceeding to the final gas-purification tower from which it will be piped to Melbourne. Each stage of the process is explained by a panel of text, which is illuminated in sequence by an automatic time-switch.

Extension to the Rowett Research Institute

Through the generosity of the Wellcome Trust, the Rowett Research Institute, Aberdeen, is now able to go ahead with the erection of a building to house the special equipment for research in animal nutrition which the Rockefeller Foundation was prepared to grant to the Institute if a suitable building were put up for it. These awards by the Wellcome Trust and the Rockefeller Foundation—up to £5,000 and £4,900 respectively—will now permit the staff of the Institute to isolate and prepare, in larger quantities than can at present be achieved in its laboratories, microbial, plant and animal constituents for further identification, analysis and *in vivo* testing.

The Library Association

The annual conference of the Library Association will be held at Folkestone during September 18–21, under the presidency of Mr. Edward Sydney. The programme includes papers on international librarianship (Dr. H. Coblans, head of the Information Service

of the European Organization for Nuclear Research), libraries in colleges of technology (Mr. L. L. Ardern, librarian of the College of Technology, Manchester), libraries of the learned societies (Mr. K. D. C. Vernon, librarian of the Royal Institution), and on "Science, Humanism and Libraries" (Mr. D. J. Foskett, librarian and information officer of the Metal Box Co., Ltd.). There will also be an exhibition of books and library equipment. Further information can be obtained from the Secretary, Library Association, Chaucer House, Malet Place, London, W.C.1.

Ministry of Agriculture Postgraduate Awards

THE Ministry of Agriculture, Fisheries and Food has awarded the following postgraduate research and training scholarships in agricultural economics, agricultural engineering, husbandry and farm management, tenable in the first instance at the university or institute shown for periods of up to two years: *Agricultural Economics:* M. J. Dorling (Oxford), B. B. Perkins (Manchester), Miss P. M. Prosser (Reading), P. F. Romney (University College of Wales, Aberystwyth); *Agricultural Engineering:* T. H. E. Harrison, S. Moore and M. R. Potter (King's College, Newcastle upon Tyne); *Husbandry:* D. M. Allen (Nottingham), G. W. Arnold (Wye College), W. J. M. Black (King's College, Newcastle upon Tyne), M. W. Case (Long Ashton Research Station, Bristol), D. C. Dalton (University College of North Wales, Bangor), J. L. Hammerton (University College of Wales, Aberystwyth), B. Roscoe (King's College, Newcastle upon Tyne), P. J. M. Sale (Reading), D. B. J. Thompson (Reading), L. J. White (Wye College); *Farm Management:* D. Hardy (Reading), P. M. Harris (Leeds), D. Wilman (Leeds).

As part of the Conditional Aid Programme, the Ministry of Agriculture, Fisheries and Food announces that the following postgraduate scholarships have been awarded in farm management, tenable at the universities shown for a period of one year: B. J. F. James (Oxford), G. J. Tyler (London).

The Nature Conservancy: Awards for 1956

THE Nature Conservancy announces the following awards of research studentships for postgraduate training in ecology, tenable for periods up to three years at the universities shown: *Botany:* C. D. K. Cook (Cambridge); K. A. Kershaw (University College of North Wales, Bangor); A. Pettet (Southampton); Miss P. J. Warwick (Birmingham). *Zoology:* B. C. Clarke (Oxford); O. W. Heal (Durham); Miss J. Kear (Cambridge); G. H. Manley (Oxford). *Geology:* M. P. Kerney (London).

Physical Society: Awards and Officers for 1956–57

THE Council of the Physical Society has made the following awards for the year 1957: *Guthrie Lecture*, Prof. H. C. Urey; *Charles Chree Medal*, Sir Edward Bullard; *Duddell Medal*, Dr. C. E. Wynn-Williams; *Charles Vernon Boys Prize*, Dr. L. Essen.

The following have been elected officers of the Society for the session 1956–57: *President*, Prof. N. F. Mott; *Vice-Presidents*, Dr. A. B. Wood, Prof. S. Devons, Prof. F. Llewellyn Jones, Prof. H. Jones; *New Members of Council*, Dr. V. E. Cosslett, Dr. D. Gabor, Mr. E. S. Shire; *Honorary Secretaries*, Dr. C. G. Wynne and Dr. H. H. Hopkins; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Treasurer*, Mr. A. J. Philpot; *Honorary Librarian*, Dr. R. W. B. Pearse.

Announcements

MR. A. L. BACHARACH has retired after more than thirty-six years on the staff of the Glaxo organization. His services in a consultative capacity are being retained for continued editorial work on "The Glaxo Volume" and on papers written by members of the Company's scientific staff for publication in scientific and medical journals.

THE Ministry of Supply announces the following appointments at the Royal Aircraft Establishment, Farnborough: Mr. E. C. Cornford, to be head of the Guided Weapons Department; Mr. D. J. Lyons, to be senior superintendent, Ballistic Missiles Division of the Guided Weapons Department; and Mr. P. A. Hufton, to be senior superintendent, Supersonics Division of the Aerodynamics Department. Mr. Cornford, Mr. Lyons and Mr. Hufton have all been promoted to the grade of deputy chief scientific officer on taking up their new appointments.

THE Institution of Electrical Engineers is arranging a convention on "Ferrites", which will be held in London at the Institution during October 29–November 2. The topics to be discussed will be the theory, preparation and properties of ferrites; microwave applications; square-loop applications; radio and television applications; and carrier-frequency applications. More than fifty papers will be read. Delegates will be attending from France, Germany, Holland, Sweden, the United States and, it is hoped, from the U.S.S.R. Further information can be obtained from the Secretary of the Institution at Savoy Place, London, W.C.2.

THE Clay Minerals Group of the Mineralogical Society is holding a meeting in London on November 2, at which "Clay Minerals and Soil Mechanics" will be discussed. Civil engineers and geologists will be particularly welcome at this meeting. Offers of papers and inquiries should be sent to the secretary of the Group, Dr. R. C. Mackenzie, at the Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen.

THIS year's Convention of Chemical Sciences of the Société de Chimie Industrielle will take place in Paris during November 18–December 3 and will include a number of meetings (to be held during the dates indicated): an international congress of industrial chemistry (November 18–24); a European congress on corrosion (November 18–24 and on December 3); a European conference on chemical engineering (November 22–24); the Paris technical meetings of the Society (November 26–30); and a chemical, rubber and plastics exhibition (November 22–December 3). The first two will be at the Maison de la Chimie, and the others in the Palais des Congrès and the Parc des Expositions at the Porte de Versailles. Further information can be obtained from the Société de Chimie Industrielle, 28 rue Saint-Dominique, Paris 7e.

MESSRS. Oliver and Boyd have written pointing out that the price of "Physiology and Biochemistry of Lactation", by Dr. S. J. Folley, is incorrectly given in their advertisement in *Nature*, September 1, supp. p. iv, as 63*s.*; it should read 18*s.* 6*d.*

ERRATUM. In the communication on "Relationship between the Amine Contents of the Two Adrenal Glands of the Cat" by Drs. K. R. Butterworth and M. Mann in *Nature* of August 18, p. 363, legend to Fig. 1, for "hatched" read "clear".

THE ROCKEFELLER FOUNDATION

GRANTS made by the Rockefeller Foundation for the second quarter, 1956, have recently been published. The following are some examples of work being supported by the Foundation to a total of nearly seven million dollars.

For the first time a high-powered nuclear reactor will be equipped with a special opening to provide streams of energy solely for medical and biological research. The design of the new 1,000 kilowatt nuclear reactor now under construction by the Massachusetts Institute of Technology is being altered to include an extra port on one of its faces. The Rockefeller Foundation has appropriated 250,000 dollars for the addition of this special medical facility.

Research on low-cost, protein-rich foods to improve the diets of food-deficient populations will be the object of two projects which the Rockefeller Foundation will assist during the next three years. A grant of 250,000 dollars to the U.S. National Research Council will be used for studying the nutritional value of proteins in products available in underdeveloped countries. The London School of Hygiene and Tropical Medicine in England will use a grant of £17,000 for research on the biological value of proteins in tropical foodstuffs.

The Rockefeller Foundation has renewed its aid to the Rural University of the State of Minas Gerais, Brazil, with a grant of 200,000 dollars for the further development of its School of Agriculture and Agricultural Experiment Station during the next three years.

To support a programme of research on plant and animal genetics, under the leadership of Profs. H. J. Muller, T. M. Sonneborn and R. E. Cleland, the Rockefeller Foundation has made an outright grant of 350,000 dollars to the University of Indiana—an important centre for genetics research. The grant will enable Prof. Muller to continue his research on the modifications of individual genes. Prof. Sonneborn has developed an almost uniquely personal field of study by utilizing the rapidly reproducing *Paramecium* to show that inheritable characters depend not only upon chromosomal structures within the cell nucleus, but also upon elements which may be found in the cytoplasm and which behave in part like genes and in part like viruses. This discovery may have an important bearing on research in the heredity of mammalian cancer. Prof. Cleland, applying the genetic theory to the evolution of plants, has shown how a stable recombination of genes can be selected by environmental pressures to produce entirely new species. The work of the Indiana group is also being supported by the Atomic Energy Commission, the National Science Foundation and the American Cancer Society.

A 260,000-dollar grant will be used over the next three years for purchasing basic research equipment for two newly created science institutes at the University of Copenhagen. New buildings now under construction will house the institutes. The Institute of Biology's new building will permit expansion of existing departments of the Faculty of Science and the creation of new ones. The Marshall Plan, the Carlsberg Foundation, industry and the Danish State have combined to furnish funds for construction. The Institute of Experimental Medicine and Surgery, where research is concentrated in areas of medicine between the purely basic sciences and clinical fields, will also have new quarters. Danish insurance companies contributed a major share of the building fund, which was augmented by a government grant of land and money. Danish botanists, who have made significant contributions in the study and cultivation of arctic plants, will also have a new cold house where meteorological conditions in Greenland can be approximated. A portion of the current Rockefeller grant will be matched by funds from Danish sources for construction of the cold house as an adjunct to the Institute of Biology.

Of the many research laboratories which are making rapid advances towards an understanding of the nature of viruses, one of the most prominent is that of Prof. Barry Commoner at Washington University, St. Louis, Missouri. For general support of Prof. Commoner's research programme, the Rockefeller Foundation has appropriated 165,000 dollars, available during the next four years.

The collaborative biological and biochemical researches in genetics, cytology and evolution at the Johns Hopkins University, an integrated programme of the Department of Biology and the McCollum-Pratt Institute, will be supported by an outright Rockefeller Foundation grant of 100,000 dollars. Prof. W. D. McElroy, director of the Institute and newly appointed chairman of the Department of Biology, will lead the consolidated research programme. Prof. B. H. Willier, distinguished embryologist and recently retired chairman of the Department of Biology, will continue to be active in research.

Support for an unusual biological research programme in a liberal arts college setting will be continued by an outright Foundation grant of 100,000 dollars to Amherst College. Inaugurated at Amherst in 1934, the research activity is concentrated in genetics and embryology. Under the leadership of Prof. Harold H. Plough, chairman of the Department of Biology, the work has resulted in a substantial increase in the number of students entering on careers in the biological and medical sciences.

The molecular mechanisms by which fungicides produce their effects in controlling plant diseases will be studied intensively in a new research project at the Boyce–Thompson Institute for Plant Research, Yonkers, New York, directed by Dr. George E. McNew. A grant of 105,000 dollars from the Rockefeller Foundation will give partial support to this project over a five-year period.

To further the development of agriculture in Puerto Rico, the Bureau of the Budget of the Commonwealth will review the organization and administration of insular agricultural agencies through a survey to be supervised by Dr. José Noguera, director of the bureau. The Rockefeller Foundation has appropriated 85,000 dollars to the Commonwealth of Puerto Rico to assist with the expenses of the survey during the next two years.

As part of its world-wide programme to investigate and assist investigations of arthropod-borne virus diseases, the Rockefeller Foundation has appropriated about 73,800 dollars, available over the next five years, to the University of Malaya, Singapore, to aid further research on Japanese *B* encephalitis and other virus diseases by the Department of Bacteriology.

In support of basic research on the nature of viruses, the major effort of the Walter and Eliza Hall Institute of Medical Research, Australia, an eight-year grant of 60,000 dollars has been made by the Foundation. The programme dealing with various phases of virus research is under the supervision of Sir Macfarlane Burnet, a leading investigator of the biology of viruses and director of the Institute, whose studies on the genetics of influenza viruses have resulted in a series of highly important findings.

Two Rockefeller Foundation grants totalling 80,000 dollars have been made to Balwant Rajput College in India to aid rural students and to promote the development of an agricultural training centre on a new 436-acre experimental farm. An outright grant of 10,000 dollars will provide a scholarship and revolving loan fund for local students. The second Rockefeller appropriation of 70,000 dollars will be used over a three-year period for building and equipping classrooms, laboratories and a library at the new site of the College of Agriculture. The College, affiliated with Agra University, is successfully bridging the gap between agricultural theory and local practice in its efforts to improve rural life.

The biochemical research of Dr. J. H. Quastel, director of the Institute of Special Research in Cell Metabolism in Montreal, will be aided by a new five-year grant of about 56,650 dollars to McGill University. The work of Dr. Quastel has been supported by the Foundation since 1936, when he held a medical sciences fellowship. Dr. Quastel will conduct a new series of laboratory studies of the effects on the processes of cell metabolism of tranquillizing and other drugs used in the treatment of mental illness. One of the first biochemists to apply modern biochemical methods to study of the brain, he will return to this field of his earlier interest in view of important recent clinical findings on drug therapy and psychosis. His early discovery of the mechanism of action of barbiturates in depressing brain metabolism formed the basis of much of the later work done in this area. More recently, Dr. Quastel has been working with intermediate carbohydrate metabolism, certain aspects of protein synthesis, and the relation between proteins and fats.

A national survey of the attitudes of newspaper and magazine readers toward science and science news, sponsored by the U.S. National Association of Science Writers, will be financed by a 70,000 dollars grant from the Rockefeller Foundation. Available over an 18-month period, the grant will make possible a 2,000-person poll to be conducted by the Survey Research Centre of the University of Michigan. The grant will be administered by New York University.

An interdisciplinary research project on the relationship of cultural patterns and personality, at the Nagoya University, Japan, will be financed in part by a 60,000-dollar grant, available over a three-year period, from the Rockefeller Foundation. Prof. Tsuneo Muramatsu, professor of neuropsychiatry at Nagoya Medical School, will direct the study.

A research and training programme in Middle Eastern economic and cultural geography will be established by the University of Durham, to enable a group of scholars to study in the Middle East. In support of the project during a five-year period, the Rockefeller Foundation has appropriated £16,925 to provide a series of postdoctoral and junior fellowships. Prof. W. B. Fisher, head of the Department of Geography, will direct the programme.

The University of Cambridge will inaugurate a research programme in experimental animal psychology with partial aid from a Rockefeller Foundation grant of £15,000, available during the next five years. The new programme will be developed as the primary research interest in the Department of Experimental Psychology under the direction of Prof. Oliver Zangwill.

A new method of analysing changes in the birth-rate, the cohort system, will be used for assessing the main factors influencing population growth in the United States by the Scripps Foundation for Research in Population Problems at Miami University, Oxford, Ohio. Dr. P. K. Whelpton, director, will conduct a two-year study with Rockefeller Foundation support of 40,000 dollars. The cohort system uses groups, or 'cohorts', of women born in the same year and follows their child-bearing experience during the course of their reproductive life. Analyses based upon the cohort tables together with other data will be used by the Scripps Foundation group to prepare new and more accurate estimates of future population growth in the United States.

The deterioration of stored grain, a food problem of world-wide importance, and the basic chemical changes occurring in seed under varying storage conditions, will be studied by a group at the Kansas State College led by Dr. Max Milner, a distinguished cereal chemist. The three-year project will be financed by a 36,000-dollar grant.

Research equipment for a new laboratory of biochemistry at the University of Ferrara, Italy, will be provided over the next three years by a grant of 40,000 dollars from the Rockefeller Foundation. The new laboratory is under the direction of Prof. Enzo Boeri.

The School of Medicine of the University of Wisconsin will institute a research programme in medical genetics with partial support from a three-year, 25,000-dollar grant from the Rockefeller Foundation. Dr. Newton Morton, formerly a member of the Atomic Bomb Casualty Commission in Japan, will direct the programme.

Among other awards are: a total of 950,000 dollars to three Indian medical schools; a total of 365,000 dollars to three Brazilian medical schools; a grant of 290,000 dollars to a Japanese medical school; a grant of 250,000 dollars in support of the programme in international student exchange of the Institute of International Education, New York; a grant of 111,600 dollars to the American Library Association for the maintenance of an overseas library planning and development office.

Other grants have been awarded to institutes and individuals in the United States, Canada, Latin American countries, most European countries, Iraq, India, Pakistan, Thailand, Australia, Japan and the Philippines.

One hundred and thirty-one fellowships were awarded by the Foundation during the second quarter of 1956. These were distributed as follows: agriculture, 31; biological and medical research, 17; humanities, 31; medical education and public health, 41; social sciences, 11.

GRASSLAND AND THE FEEDING OF LIVESTOCK

THE Nutrition Society held a meeting in Reading on July 20 which took the form of a symposium on "Grassland and the Feeding of Livestock", a subject of major importance in relation to the improvement both of the efficiency of animal production and of human nutritional status. Prof. H. D. Kay (Shinfield) was in the chair.

The first contributor was Dr. William Davies (Hurley). In an introductory paper he laid emphasis on the unstable nature of the grassland sward, ever changing in one direction or another in response to environmental changes. Following the destruction by man of the primeval forests which at one time covered the greater part of the present cultivable area of Great Britain and his subsequent agricultural efforts, several types of grassland of different botanical composition and of differing agricultural value developed. These can be conveniently divided into six major types, from the ryegrass–white clover pasture at the better end to the *Molinia-Nardus* pasture at the poorer. Far from stable, the poorer types can be improved under suitable management—including fertilizer treatment and grazing—or the better types can deteriorate when improperly managed. In one recorded trial, for example, fertilizer (calcium, nitrogen, phosphorus and potassium) treatment of a mainly *Molinia* hill pasture not only completely changed the botanical composition of the sward in a few years but also gave nearly ten times the yield of herbage (measured in lb. of dry weight per acre per year). Even grazing alone (without added fertilizer) of such a pasture more than doubled the yield of dry matter per acre in less than ten years. One of the effects of the fertilizer treatment was to bring in species, such as rough-stalked meadow grass and white clover, which were not present at all in the original sward. Good pasture management and knowledgeable fertilizer treatment not only give greatly increased yields of consumable grass, but also extend the normal grazing season into the autumn and spring.

Prof. W. Holmes (Wye) discussed the so-called law of diminishing returns in relation to the application of increasing quantities of nitrogenous fertilizers to crops and grass. For cereal and root crops the response curve is logarithmic; thus, it has been found that for cereals each successive fertilizer dressing of 28 lb. of nitrogen per acre increases (on the average) the yield by 53 per cent of the previous increment. For leafy crops such as kale, the response is much greater, 28 lb. of nitrogen per acre increasing the yield by 78 per cent of the previous increment. For grassland the percentage response is greater still; given suitable temperatures and water supply, it is almost linear up to an application of 300 lb. of nitrogen per acre. Application of nitrogen also increases the efficiency with which water is used by the growing grass. A further factor arises when grass is grazed—namely, the return of nitrogen and other grass nutrients in the form of dung and urine; in effect, some of the fertilizer nitrogen is used more than once. Response to nitrogen treatment depends on climate, water supply, season and frequency of application. The situation is complicated since, owing to its content of legume, the normal clover–grass sward derives directly or indirectly substantial quantities of nitrogen from the clover (of the order of 150–250 lb. of nitrogen per acre per year). Application of small amounts of fertilizer nitrogen in spring is very harmful to the clover and gives, therefore, poor total response; but heavy dressings give good responses in terms of total yields per acre, since grass is greatly stimulated though the clover is suppressed.

The capacity of grass to respond to large amounts of nitrogen is outstanding, and from the point of view of farm economics, very cheap cattle food may be produced by the skilful use of nitrogenous fertilizers. Provided there is also mastery of the technique of the utilization of grass by cattle, the results in animal production may be very profitable. This latter aspect was dealt with by Mr. A. S. Barker (London), who, in his paper on fertilizer nitrogen and milk production from grassland, emphasized the great importance of skilled management in making optimum use for grazing animals of the increased production of grass. Taking one year with another, the joint effect of fertilizer plus management can be measured in a dairy herd by the output of milk per cow per year or per acre of grassland per year. Given appropriate grassland and livestock management, it has been shown in a series of trials on farms that the application of increasing quantities of nitrogenous fertilizer from 23 lb. of nitrogen per acre in steps of 23 lb. up to 115 lb. will increase the output of utilized feed at the rate of about 2–3 cwt. of 'starch equivalent' per acre for each increment of 23 lb. of nitrogen, and that at a practically linear rate. Mr. Barker stated that, from the profit-and-loss point of view, at prices current during the past two years, £1 spent on fertilizer has given a considerably greate return in milk production than £1 spent on purchased food.

Mr. W. F. Raymond (Hurley) spoke on the measurement of pasture output. Most systems of pasture evaluation take little account of two of the main characteristics of pasture output—namely, that it is made up of a number of harvests in any one year, and that management in one year affects yields and persistence in subsequent years. Optimum management methods vary with different pastures. The total annual yield is of less importance practically than the distribution of that yield between different months of the year, while such herbage characters as persistence, palatability and winter greenness are also of major importance in relation to the evaluation of any particular sward for stock. Pasture investigation requires measurement of effective output from a pasture over a relatively short period; some techniques which have apparently been valid for assessing output over a whole grazing season are inadequate when applied to short grazing periods. As a yardstick, live-weight gains, at least over short periods, are not very helpful; milk production is a rather more sensitive reflexion of pasture output than live-weight gains, but is even more dependent on management. Two methods of assessing pasture intake are being investigated, involving herbage cutting or fæcal measurements with an indigestible tracer such as chromic oxide for determining the quantity of fæces voided, and analysis of the amount of lignin in the fæces to determine the digestibility of the herbage, with the aid of a 'fæcal index' based on indoor experiments on digestibility.

Dr. M. J. Head and Mr. J. A. F. Rook (Shinfield) discussed certain effects of spring grass on rumen digestion and the metabolism of the dairy cow, particularly in relation to hypomagnesæmia. Heavy

dressings of nitrogenous fertilizer in early spring produce a rapid growth of succulent herbage containing a high percentage of crude protein. If this herbage is grazed by dairy cows as their sole diet, it provides an unbalanced ration containing excess of protein equivalent. The effect of the sudden change from the winter ration to such an unbalanced diet in the spring is not infrequently to induce severe hypomagnesæmia and 'tetany'.

Rumen fermentation of such spring herbage has been shown to lead to increased production of ammonia; the ammonia is absorbed from the rumen into the blood stream and can be demonstrated in the portal vein and sometimes in the peripheral blood. This production of ammonia in the rumen can be depressed by feeding starch. Ammonia in the circulating blood may be toxic in relatively low concentrations.

Hypomagnesæmia in the cow in spring is due in part to the low availability to the animal of the magnesium in spring herbage, and in part to the relatively low daily intake of magnesium in the grass diet in comparison with the intake from winter feed. The hypomagnesæmia is most severe in those cows with the highest levels of ammonia in the blood. If the ammonia concentration in the rumen of a cow is artificially raised, the magnesium-level in the blood is depressed. On the other hand, low level of magnesium in the blood induced by feeding young spring grass may be raised again by feeding maize starch, which at the same time causes a drastic reduction in ammonia-levels in the rumen.

The final paper in this symposium, by Dr. W. A. McGillivray (Palmerston North, New Zealand) and Dr. S. Y. Thompson (Shinfield), was concerned with the influence of pasture on the vitamin A and carotene in the milk of cows. Calculation shows that, in the average human diet in Britain, cows' milk contributes about 20 per cent of the daily requirements of vitamin A. Three factors influence the vitamin A content of cows' milk, as follows: stage of lactation —colostrum and very early lactation milk are richer in both carotene and vitamin A than milk secreted during the rest of the lactation period; hormonal influences—the thyroid plays a part in carotene metabolism in the cow; and feed of the cow—the major factor. The cow converts carotene inefficiently into vitamin A. Intake of carotene is, however, probably quite sufficient on pasture to produce butter with high vitamin A potency; but on a winter diet this potency diminishes markedly. In New Zealand, where cows—predominantly Jerseys—are fed outdoors on pasture throughout the year, a uniformly high vitamin A potency in milk fat might be expected. In fact, the potency depends in large part on the botanical composition of the herbage, less carotene being absorbed and utilized on a pasture containing much clover than on one containing little clover. The tocopherol content of milk fat is likewise decreased on a high-clover pasture. There are probably two forms of carotene in blood plasma, one which contributes little to milk-fat – carotene levels and is associated with vitamin A alcohol, and the other which is present on a carotene-containing diet and is associated with vitamin A ester and dietary fat in the chylomicrons, taken up directly by the mammary gland to contribute to the synthesis of milk fat.

Quickly growing, 'improved' pasture produces a number of metabolic disturbances in sheep and in cows in New Zealand. Muscular dystrophy is found in young sheep (though there is adequate tocopherol in the pasture). There seems to be an anti-vitamin D factor in pasture, producing rickets in young lambs. Bloat in cows is a serious problem in New Zealand—drenching the cows with oil appears to be an effective treatment. Facial eczema in sheep, associated with lush pasture, also causes serious losses in some years; its cause is not yet understood.

Each paper in the symposium was followed by a short but lively discussion; from these discussions it is clear that two of the present urgent needs in relation to the feeding of farm livestock on pasture are: first, more knowledge of those constituents of rapidly growing herbage which at times upset the metabolic balance of grazing ruminants; and second, how such upsets can be most conveniently prevented in practice on the ordinary farm, without diminishing the advantages of modern methods for improving the efficiency of grassland production.

H. D. KAY

THE 1956 CAMBRIDGE SUMMER SCHOOL IN PHYSICAL CHEMISTRY

THE rate at which modern science advances continues to increase, and most scientists, though confining their activities within narrow channels, find themselves incapable of synchronizing with the acceleration. One way of contending with this situation is by means of the refresher course, where a small number of lecturers who have paid special attention to certain selected subjects give brief reviews on recent developments, stressing general theoretical principles rather than detailed experimental technicalities. With this object in mind, the Department of Physical Chemistry of the University of Cambridge has arranged summer schools, at intervals of three years, since the end of the Second World War.

This year's summer school, held during August 18–25, began with an inaugural lecture on Saturday night by the head of the Department, Prof. R. G. W. Norrish, who outlined briefly the history of the University of Cambridge and in particular of the origin and growth of its scientific departments. Prof. Norrish is particularly well qualified for such a lecture, being a Cambridge man in every sense of the word; he was born in the City, and, before entering the University, was educated at the Perse School, the ancient hall of which is now one of the most attractive features of his Department. The lecture, though full of fact, was interspersed with adequate humour, and helped to create an atmosphere of welcome to the 116 visitors who attended the school. The first real mingling of the visitors among themselves and with many Cambridge dons began in a garden party held on Sunday in the pleasant grounds of Sidney Sussex College.

The scientific course, which started on August 20, consisted of a course of fourteen lectures devoted to two broad topics, both of which are rapidly developing, namely, the applications of spectroscopy to chemical problems and the application of intermolecular force theory to the study of fluids. The first lecture was given by Prof. H. C. Longuet-Higgins on the nature of intermolecular forces and the properties of imperfect gases. Direct electrostatic, induction and dispersion forces play a part in determining intermolecular potential energies, and must be supple-

mented by repulsive forces, which predominate when molecules get very close together. This led naturally to a treatment of the liquid state of matter, which was given by Dr. E. A. Moelwyn-Hughes. Theories of free space, moving holes and anharmonic oscillators were reviewed, and new data presented on the heat capacities of liquids at constant volume. Both these lecturers spoke later, and from different angles, on current theories of solutions of non-electrolytes. Longuet-Higgins showed how the thermodynamic properties of regular solutions could be derived on a statistical basis, while making a small number of assumptions concerning the form and relative magnitude of the three interaction-energy terms. Dr. Moelwyn-Hughes explained how the theories of van Laar, Hildebrand and Scatchard can be derived in terms of a simple model of a solution and of the partition function to which it leads. Dr. J. N. Agar gave two lectures on selected topics dealing with solutions of electrolytes. He dealt with heats and entropies of hydration of ions, with the limitations of Born's theory, and with a new hypothesis on solvation which can explain the magnitude of the ionic activity coefficient in quite strong solutions. Mr. R. P. Bell, of Oxford, one of the visiting lecturers, spoke on the hydrogen bond and the very wide range of phenomena connected therewith. The hydrogen bond deserves to be treated as distinct from other types of bonds. Our knowledge in this field began with the study of the interaction of two carboxylic acids, and now extends to the interpretation of the so-called anomalous properties of hydroxylic liquids and solutions.

The discussion on modern developments in spectroscopy was opened by Mrs. D. M. Agar, who gave an account of infra-red and Raman spectra, with their application to such problems as rotational isomerism and forbidden transitions. There followed a lecture by Prof. W. C. Price, of King's College, London, the second visiting lecturer, on observations made in the visible and ultra-violet regions. Electronic spectra and ionization potentials of polyatomic molecules are now telling us much about the pattern of electrons in molecules and of their energy states, just as atomic spectra long ago provided Rutherford and Bohr with a picture of electronic arrangements and energies in free atoms. The nature of the chromophoric group in the normal and excited states of the molecule can be understood in terms of a fairly simple free-electron theory. Among the more spectacular spectroscopic developments of the past decade are those associated with the production of free radicals under the influence of an intense flash and with their characterization during their transient existence. The first lecture on this subject was delivered by Prof. Norrish, who first described in general terms the methods of kinetic spectroscopy and their application to isothermal reactions of free radicals. Among the many problems which have been tackled by the new method are the rates of combination of free atoms, the mechanism of the interaction of carbon monoxide with various gases and the conversion of the vibrational energy of the oxygen molecule into energies of other forms. The marked advances made in radio-frequency spectroscopy, and the related topics of nuclear magnetic resonance, were treated in two lectures by Dr. T. M. Sugden. Moments of inertia, intermolecular distances, valency angles and dipole moments are among the molecular properties which can be measured by the radio-frequency method. Dr. Sugden's third lecture dealt with the applications of spectroscopy to the study of flames. The concentration of free electrons in flames can now be determined fairly accurately, and the results can be applied to estimate the energy required to dissociate molecules into radicals, and complex radicals into simpler ones. Values of the bond energies thus found have been confirmed by other means. The course concluded with a lecture by Prof. Norrish on the study of explosions by means of kinetic spectroscopy. The mechanisms of the reaction between hydrogen and oxygen and of the oxidation of hydrocarbons have been studied by the new method, which has served also to throw light on the nature of the knock and anti-knock effects met with in combustion.

Each lecture was followed by discussion, and the two morning lectures at 9.30 and 11.15 were separated by an interval when discussions continued over coffee. One cannot attend lectures and take part in discussions the whole day through, and the organizers of the summer school had wisely provided amenities to fill in the leisure hours. Most of the men attending the school were housed in Corpus Christi College and Pembroke College, and the five women were accommodated in the Corpus Christi College Hostel. There was a reception in the Guildhall on August 21, when scientists forgot that they were scientists and relaxed in dancing or sipping wine under the influence of pleasant music. Mr. Hugh J. McLean gave an organ recital in the chapel of King's College on August 23, when the visitors had an opportunity of listening to some of the fugues and voluntaries of Orlando Gibbons, a chorister of the College in 1596, and of Bach, Mozart, Franck and Willan. Those who attended the school were also entertained by Prof. and Mrs. Norrish at their home and by the senior members of his staff at evening parties given at their homes or in their colleges. On August 24 the school and a number of guests dined in the hall of Pembroke College under the presidency of Prof. Norrish, with Sir Owen Wansbrough-Jones, chief scientist of the Ministry of Supply, as principal guest.

Most of those attending the school were research workers or those engaged in teaching physical chemistry. Fifty-four came from industrial research establishments, which included Bakelite, British Celanese, British Rayon, Bush, Boake Roberts, Courtaulds, Distillers, Dow Chemical Co., Esso, J. Lyons, Imperial Chemical Industries, Laporte, Monsanto Chemicals, Metropolitan-Vickers, Philips (Eindhoven), Pilkington's, Rolls-Royce and Shell. There were thirty-two academic scientists from the Universities of Belfast, Berlin, Columbia, Copenhagen, Delft, Geneva, Glasgow, Göttingen, Hong Kong, Leyden, Liège, London, Marburg, Moscow, Prague, Southampton, Texas, Tokyo, Virginia and Warsaw. There were nine representatives of research and development establishments of the various Ministries of the Crown and six teachers from public and grammar schools.

It is almost impossible to over-rate the importance of the contacts established in such a gathering. The great number of questions put to the lecturers in private conversations proved that the topics dealt with were of immediate interest and value. The lecturers themselves have also learnt much of what is happening in wide fields of research enterprise outside their own university. Ideas were freely exchanged and, like the poet's joy, improved on being poured from one vessel to another. There was a refreshing frankness in all the school's deliberations, and there was a free trade of thought.

No account of the physical chemistry summer school at Cambridge would be complete without some reference to the happy human relationships which were established, and in many cases strengthened, between academic research workers and industrial research workers, and between British scientists and foreign scientists. Politicians have yet to learn that scientists are men who are kindly disposed towards one another, have a common faith and interest in their subject and desire nothing more than freedom to study Nature and to subjugate her to the benefit of mankind. A gathering of this kind can be lightly described as just another conference, conducted with evident pleasure, and not unprofitably. On the other hand, its consequences are incalculable. To bring industrial and academic research workers together is a vital step in furthering the national economy. To bring foreign scientists from all over the world—including that part which lies beyond the 'iron curtain'—into harmonious contact with British scientists is to increase the volume of international goodwill, in an age when that commodity is none too abundant, and when the contribution of the scientists to it is paramount.

E. A. MOELWYN-HUGHES

GLAZED FROST IN ENGLAND OF JANUARY 1940

GLAZED frost, the phenomenon of rain or drizzle falling on a frozen earth and covering everything with a layer of clear ice, is not of very frequent occurrence in Britain and, when it does occur, it is usually short-lived and quickly followed by an influx of air warm enough to melt the ice. In the United States it is sufficiently common and severe to be called an ice storm. The main economic effects are severe disturbance of transport by the very slippery roads and paths and destruction of overhead telegraph and power lines. The precipitation falls from clouds at a temperature above freezing point through a low-lying layer of air at a temperature below freezing point. The supercooled droplets freeze on striking the ground, trees, telegraph wires and so on, forming a coating of clear slippery ice. Usually the phenomenon is transitory because it is produced by the fairly fast-moving warm front or warm occlusion of a winter depression.

During January 25–February 4, 1940, however, as is described by Dr. C. E. P. Brooks and Mr. C. K. M. Douglas in Geophysical Memoir No. 98 of the Meteorological Office, entitled "Glazed Frost of January 1940"*, intense persistent glazed frost formed over much of England south of a line from the Humber to the Mersey except East Anglia. It was especially intense along a wide belt from North Wales to Kent. The ice formed cylinders up to 2½ in. in diameter on telegraph wires, twigs, etc., and a coating an inch thick on the ground. Telegraph poles and trees collapsed in large numbers under the weight of the ice. The memoir contains some vivid photographs of the ice which the authors describe as probably unequalled, certainly in at least a century, for extent and persistence in Great Britain.

The meteorological circumstances producing the ice are fully described. At the time there was an anticyclone over Scandinavia and a depression south-west of Iceland. Between these systems a very cold south-easterly wind blew across most of the British Isles with temperatures between 25° and 30° F. inland. Two warm fronts moved successively early in the period from the south-west across Ireland, south-west England and Wales and then oscillated slowly backwards and forwards over the mouth of the Channel and south-west England, bringing the rain which fell through the cold surface air to produce the glazed frost. Finally, on February 3, the warm air swept northwards, displacing the cold south-easterly current over the country and melting all the ice. The chief technical meteorological interest lies in the motion of the fronts, which over a considerable period departed widely from that given by the components of geostrophic wind normal to them.

The differences were abnormally large. One warm front over south-west England on January 28, which should, on the geostrophic basis, have moved at the rate of 15 m.p.h. to the north-east, moved at 5 m.p.h. south-west. The differences between actual and geostrophic wind are too large to be accounted for by accelerations associated with pressure changes, and the best suggestion is that of a departure caused by turbulent friction in the frontal zone in which the wind changed rapidly in direction. This friction introduces a term in the hydrodynamic equations proportional to the coefficient of turbulence, multiplying the second differential coefficient with respect to height of the wind component parallel to the front. It is shown in the memoir that this would have the right order of magnitude.

* Air Ministry: Meteorological Office. Geophysical Memoir No. 98: Glazed Frost of January 1940. By Dr. C. E. P. Brooks and C. K. M. Douglas. Pp. 40+10 plates. (M.O. 584*f*.) (London: H.M.S.O., 1956.) 7*s*. 6*d*. net.

THE BUKIDNON OF MINDANAO

PROF. FAY-COOPER COLE'S recent field-work monograph on the people of one of the larger islands of the Philippines, entitled "The Bukidnon of Mindanao"*, is an unusual publication. Had it been written by an anthropologist as a result of recent field-work, it is doubtful whether there would have been any justification for having it published. But the field-work dates from 1910, and the author is a professor of anthropology (emeritus) writing in 1956. The situation has its possibilities, and on commencing to read the monograph one wonders whether the author will succeed in producing a work of contemporary interest on foundations that are left over from a different period. The answer is, unfortunately, no.

It would, of course, be unfair to take the author to task for not having had 1956 in mind in 1910; but it is obviously true that he has been unable to decide what to do with the material himself, and, as a result, the book is concerned with everything in general, but nothing in particular. There are good illustrations of material objects, houses and dress, all of which are interesting, but within the scope of a hundred-odd pages the text rushes through chapters with such diverse titles as "Making a Living"; "The Life Cycle, Social and Political Organization"; "The Spirit World"; "The Ceremonies"; "Music and Dancing"; "Celestial Bodies"; "Stories and Legends".

Prof. Cole seems to have had no concern for kinship, at least in 1910—which is a pity; for the Bukidnon appear to have a system of bilateral kinship on the Iban pattern, but there are scarcely

* *Fieldiana*: Anthropology. Vol. 46: "The Bukidnon of Mindanao". By Prof. Fay-Cooper Cole. Pp. 140. (Chicago: Chicago Natural History Museum, 1956.) 4 dollars.

any asides in that direction. The remarks on marriage are more tantalizing than illuminating, and social and political organization—including such headings as crime and law (four paragraphs) and slavery (two paragraphs)—merits only ten pages.

It is not that the author has no interest in the problems of social anthropology; for example, he reports the notable phenomenon—recorded also in other areas—that as the "aggressive intervention" (*sic*) of the authorities (in this case the American Governor) increased in the daily life of the people, and as they were forcefully moved into "model villages", there was a "withdrawal into the old ways in religion". With the decline of the political importance of the local headmen, the influence of the "mediums" and their ceremonies became more powerful "to the extent that they dominated the social and religious life" of the Bukidnon. But all this is merely stated and not followed up. There are, instead, descriptions of ceremonies concerned with ritual healing and with the fertility of the crops, and there are discussions on the concepts of the supernatural. However, the author seems to have worked through interpreters, and what with the unclear social background and without the backbone of a theory to give the material some coherence, these pages remain unrewarding.

The conclusion strikes a different vein. For, when the author is left with two pages, he reveals that he had in mind all the time "the attempt to account for the peopling of Central and Southern Mindanao": this aim is certainly not disclosed earlier on, nor is it pursued with much vigour. NUR YALMAN

VOLTA RIVER PROJECT IN THE GOLD COAST

THE report of the preparatory commission on the Volta River Project set up in 1953 by the United Kingdom and Gold Coast Governments was published on July 27 as a non-parliamentary paper, and the Secretary of State for the Colonies, Mr. A. T. Lennox-Boyd, said in a written answer in the House of Commons on that day that the report provides evidence of an extremely thorough examination of all the problems to be solved in a project of this magnitude. The main conclusions of the commission are that the project is technically sound and could be carried out successfully; it is not capable of significant improvement from an economic point of view, but the greatest return would be derived by achieving maximum production as soon as possible. The commission further concludes that the project should be competitive in relation to other schemes, provided that the time-table of construction is observed, a sound policy adopted in the employment and provision of living conditions for the labour force, economic stability maintained in the Gold Coast, and that the aluminium companies are satisfied that the internal cost of operating the smelter would be acceptable. The report also considers such factors as the co-ordination of the future development plans of the Gold Coast Government, the maintenance of adequate administrative and technical services, and the level of future world demand for aluminium and future developments in the generation of power from nuclear energy.

As a result of its investigations, the commission considers that the scheme, based on two stages of aluminium production, would cost £184·9 million (with a capacity of 120,000 tons a year), rising to a total of £231·3 million (with a capacity of 210,000 tons a year) compared with the estimates of £116 million and £144 million in 1952 but including also certain additional work. The commission suggests that it would be prudent to allow for a further increase of 40–50 per cent so as to obtain a realistic appreciation of the finances that might be required for the project, which would take about eight years to bring to production. This increase should not make the project less attractive provided world prices move upwards at roughly the same rate. The United Kingdom and the Gold Coast Governments and the aluminium companies have each re-affirmed their interest in the project, though none of them is yet committed to participation. They have agreed that, because of the substantial increase in the estimated capital cost, it is necessary to review both the framework and the method of finance; as the next step, the International Bank is being asked to make a general assessment of the project and to indicate the extent to which it would be willing, in principle, to participate if the two Governments and the aluminium companies reached agreement on the framework.

POLLEN CHEMISTRY

R. LUNDÉN, with the citation of some eighty-one references, has given a useful résumé of the literature of pollen chemistry (*Grana Palynologica*, 1, No. 2, 3; 1956). The protein and amino-acid content of different pollen grains has long been of special interest and practical importance, on one hand, to apiarists in search of a pollen substitute in the rearing of bees, and, on the other, to medical investigators interested in the active principle in pollen allergy.

With the development of partition chromatography, considerable advances are now being made in ascertaining both qualitative and quantitative facts regarding the amino-acid content of grains; indeed, all the common amino-acids have now been found to be present in pollens, either bound to protein or in the free state, though some important deficiencies have been reported. As the carbohydrate content of pollen grains is considered to be of less importance from the point of view of bee nutrition, this aspect of pollen chemistry has received rather less attention; but analytical data have been given for the starch, cellulose, pentosan and reducing sugar contents of the pollen of a number of species. Lipides have also been examined.

Studies of the vitamins and hormones of pollen grains have shown that, in general, they are rich in the vitamins of the B group but low in fat-soluble vitamins; some quantitative information relating to a considerable number of vitamins is now available for several species. The evidence indicates pollen to be an exceptionally good source of water-soluble vitamins, for example, of thiamine, riboflavin, pantothenic acid, nicotinic acid and ascorbic acid. Œstrogenic substances have been detected in certain pollens, and also plant growth regulating substances. Pollen enzyme chemistry likewise promises to be a particularly rich field for research. Reference is also made to the pigments, which are chiefly flavonols and carotenoids, and to the inorganic and various miscellaneous constituents.

A VIRUS RESEMBLING RUSSIAN SPRING–SUMMER ENCEPHALITIS VIRUS FROM AN IXODID TICK IN MALAYA

By Dr. C. E. GORDON SMITH

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A VIRUS (*TP*21) serologically resembling that of Russian spring–summer encephalitis has been isolated from a pool of hard ticks, *Ixodes granulatus* Supino, from forest rats caught near Kuala Lumpur. The probable importance of this finding is two-fold. First, the distribution of viruses resembling Russian spring–summer encephalitis may be wider than was previously known. Russian spring–summer encephalitis, transmitted apparently by *I. persulcatus*, occurs in widespread areas of the U.S.S.R.[1], Czechoslovakia, Slovenia and Austria[2]. The virus cannot be distinguished from that of louping ill[3], which is an encephalomyelitis mostly of sheep, but occasionally of man, transmitted by *I. ricinus* in Scotland. Russian spring–summer encephalitis in Europe and North Asia has apparently a widespread reservoir mainly in rodents and is only occasionally transmitted to man. The only obvious common factor between these areas and Malaya is the presence of *Ixodes* species, which suggests the possibility that *Ixodes* species in many parts of the world may be the vectors of Russian spring–summer encephalitis or antigenically related viruses, some if not all of which may be capable of causing disease in man. Secondly, although *I. granulatus* has not yet been recorded biting man in Malaya, it has a wide host-range, and, as planters and troops are frequently bitten by ticks, we should be alert to recognize human disease caused by this virus.

The relevant technical details are as follows: twenty-four female and one male *I. granulatus* from one *Rattus mülleri validus* (Miller) and one *R. sabanus vociferans* (Miller) were ground up and treated with antibiotics and by high-speed centrifugation. Intracerebral inoculation into day-old suckling mice (*DDM* strain) caused paralysis on the fifth day after inoculation. Passage of bacteriologically sterile brain material from these caused paralysis in adult mice on the fifth day, and in sucklings on the third day. Re-isolation in adult mice from the tick suspension was successful. Using adult mice, one hour incubation of serum–virus mixtures at 37° C. and intracerebral inoculation of ten mice per 10-fold dilution of virus, *TP*21 was tested by neutralization test against antisera to Russian spring–summer encephalitis (I am indebted to Dr. W. L. Pond for this antiserum), Japanese encephalitis, and dengue-1 viruses, of which the last two have been isolated in Malaya. The Russian spring–summer encephalitis antiserum used was the same serum pool as was used by Pond *et al.*[2,3] in their studies of Russian spring–summer encephalitis and related viruses. The latter was suspected because of the high pathogenicity of *TP*21 for adult mice, its lethality by intraperitoneal route, and because it came from *Ixodes* ticks. *VR*4609 and *VR*4610 were sera of two wild-caught *R. rajah surifer* (Miller) which had hæmagglutinin-inhibiting antibody to *TP*21. Clearly (Table 1) there was significant neutralization only by Russian spring–summer encephalitis and the *R. rajah* sera. As no other virus has so far been described with such a close antigenic relationship to Russian spring–summer encephalitis, *TP*21 must be closely related to it if not identical. The neutralizing antibodies in the two *R. rajah* probably indicate natural infection with *TP*21.

Table 1. Identification of *TP*21 by Neutralization Test in Mice versus Specific Immune Antisera

Antisera	*LD*50 titre (negative log) after incubation of virus–serum mixtures	Neutralizing index	Homologous titre of antiserum
Russian spring–summer encephalitis	4·1	790	6,300
Japanese encephalitis	6·9	1	2,500
Dengue-1	6·6	3	250
*VR*4609	4·0	1,000	
*VR*4610	4·0	1,000	
Normal rabbit (controls)	7·1	7·0	
Normal mouse (controls)	6·9	7·0	

Table 2. *p*H and Temperature Characteristics of Freshly Prepared *TP*21 Hæmagglutinin

*p*H	Reciprocal hæmagglutinin-inhibiting titre at temperatures indicated		
	4° C.	27° C.	37° C.
5·6	< 50	< 50	< 50
6·0	< 50	< 50	< 50
6·4	< 50	100	50
6·8	> 6,400	3,200	3,200
7·0	1,600	800	3,200
7·2	< 50	< 50	3,200
7·6	< 50	< 50	< 50

Apart from a passing and incomplete reference by McLean[4], there is no published account of the preparation of a chick-cell hæmagglutinin from Russian spring–summer encephalitis or a related

Table 3. Distribution of Hæmagglutinin-inhibiting Antibodies to Japanese Encephalitis and *TP* 21 in a Variety of Malayan Sera

	No. of sera tested	No. containing hæmagglutinin-inhibiting antibody to		
		*TP*21 only	Jap. enceph. only	*TP*21 and Jap. enceph.
Forest animals				
Ground rats	51	6	0	0
Tree rats	4	0	0	0
Squirrels	3	0	0	0
Birds	2	0	0	0
House pests				
Rats	6	0	0	0
Civets	2	0	0	0
Domestic animals				
Cattle	5	0	3	0
Buffaloes	27	0	0	0
Goats	2	0	1	0
Pigs	10	0	0	0
Humans				
PUO (pairs showing rise in titre)	8	0	0	0
Sera for heterophile antibody tests				
Asian	24	0	7	10
European	9	0	1	8

Table 4. Hæmagglutination Inhibition Tests with *TP*21 against Hyperimmune Mouse Sera

Immune mouse serum pools	Reciprocal hæmagglutinin-inhibiting titre with indicated antigens															
	Jap. enceph. : units				Dengue-1 : units				Dengue-2 : units				*TP*21 : units			
	1	2	4	8	1	2	4	8	1	2	4	8	1	2	4	8
Jap. enceph.	160	160	80	40	640	640	320	320	160	160	80	20	640	320	80	40
Dengue-1	< 10	< 10	< 10	< 10	160	80	160	80	20	10	< 10	< 10	320	160	40	20
Dengue-2	320	320	80	40	320	320	80	40	160	160	40	20	40	20	< 10	< 10
'Normal'	< 10	< 10	< 10	< 10	20	20	20	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

agent, which is inhibited by immune sera. However, a hæmagglutinin was prepared from *TP*21 by the method of Chanock and Sabin[5], and its *p*H and temperature characteristics when freshly prepared are shown in Table 2. Third-passage material gave a titre of 1/200,000 at *p*H 6·5 and 4° C. Using this system and acetone-extracted sera[3], a variety of sera were tested for hæmagglutinin-inhibiting antibodies to *TP*21 and Japanese encephalitis (Table 3). Six sera, all from forest ground-rats (*R. sabanus*, *R. rajah*, and *R. mülleri*), were positive only against *TP*21, but a proportion of the human and domestic animal sera which had antibody to Japanese encephalitis also had antibody to *TP*21—this probably indicates cross-reaction between *TP*21 and Japanese encephalitis, as all these sera had higher titres versus the latter than *TP*21. None of the nine pairs of acute- and convalescent-phase sera from cases of pyrexia of unknown origin, nor of the thirty-four sera received for heterophile antibody tests, showed evidence suggestive of previous *TP*21 infection.

*TP*21 was also tested by Dr. B. L. Elisberg of the U.S. Army Medical Research Unit stationed at the Institute for Medical Research, Kuala Lumpur, in a hæmagglutinin-inhibition test against hyperimmune mouse sera prepared by the method of Casals and Brown[6] and his results are shown in Table 4. These results confirm that *TP*21 is antigenically related to Japanese encephalitis and the dengue viruses (that is, it belongs to Casals' *B* group of viruses[6]), but that its behaviour differs from each of them.

*TP*21 inoculated subcutaneously into two macaque monkeys caused fever between the tenth and fifteenth day in one; similar inoculations into albino rats, and wild-caught *R. bowersi*, had no detectable effect. One of two guinea pigs inoculated intracerebrally died, but virus could not be found in its tissues; two inoculated intraperitoneally were unaffected. Adult mice were only moderately susceptible by intraperitoneal inoculation—only four out of six were killed by 10^6 intracerebral *LD*50 doses.

The implication of this very limited study is that infections with *TP*21 may be common and probably often symptomless in forest rats, and that *I. granulatus*, which is common and widespread on ground- and tree-living small mammals in the Malaysian forests, extending northwards to India, may be a vector. Neutralizing antibodies to Russian spring-summer encephalitis virus were found in a few individuals from north-west India by Smithburn *et al.*[7], and work by Pond and his colleagues of the U.S. Army Medical Research Unit (to be published) suggests that such antibodies may also occur in Malaya.

This preliminary report is submitted because, owing to the known laboratory hazards of Russian spring-summer encephalitis virus, work with *TP*21 has been suspended until its identity has been established by a reference laboratory.

[1] Rivers, T. M., "Viral and Rickettsial Infections of Man", 244 (Philadelphia, 1952).
[2] Pond, W. L., Russ, S. B., and Warren, J., *J. Infect. Dis.*, **93**, 294 (1953).
[3] Pond, W. L., and Russ, S. B., *Bull. World Health Org.*, **12**, 591 (1955).
[4] McLean, D. M., *Aust. J. Exp. Biol. Med. Sci.*, **34**, 71 (1956).
[5] Chanock, R. M., and Sabin, A. B., *J. Immunol.*, **73**, 337 (1954).
[6] Casals, J., and Brown, L. V., *J. Exp. Med.*, **99**, 429 (1954).
[7] Smithburn, K. C., Kerr, J. A., and Gatne, P. B., *J. Immunol.*, **72**, 248 (1954).

POSSIBLE CATION-CARRIER SUBSTANCES IN BLOOD

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THE existence of carrier molecules responsible for the transport of specific ions across cellular membranes has long been postulated, but no substances with the necessary chemical characteristics to fill the role have yet been recognized in biological material. As a consequence, the combination of alkali cations with molecules that are found in living matter is of particular importance to the problem of transport of ions across cellular membranes. Lipide binding of cations has been studied by Christensen and Hastings[1], Folch[2], and Baer, Buchnea and Newcombe[3]. Pyridoxal has been suggested as a carrier by Christensen[4], and the relevance of polyphosphate cation-binding to the carrier problem has been put forward by Steinbach[5]. In the case of the red cell, Solomon[6] has put forward the hypothesis that the complex of sodium and potassium ions with carrier, or carriers, should be lipide-soluble, non-dissociable in lipide, but dissociable in water solution. Thus the cation would be carried through the lipide portion of the membrane as part of a soluble carrier complex.

Human blood and plasma have both served as starting materials. Samples of whole blood were incubated at 37° C. for periods of one hour or more with potassium-42, using the techniques previously described[6]. At the close of the incubation, the blood was frozen and dried under vacuum. 0·5 gm. aliquots of the dried material were then extracted for 15 min.

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Table 1. Extraction of Potassium from Blood by Various Solvents

Solvent	Potassium extracted (m.mole/l. blood)
Diethyl ether	0·003
Benzene	0·004
Chloroform	0·009
Hot 2 : 1 chloroform–methanol	0·429

by shaking with 10 ml. of each of a variety of organic solvents, including chloroform, a hot 2 : 1 mixture of chloroform–methanol (Folch *et al.*[7] have shown that chloroform–methanol is effective in removing lipide from brain tissue, in which it is found in association with proteins), acetone, benzene, diethyl ether, *iso*-propyl ether, and petroleum ether. It can be seen from Table 1 that the chloroform–methanol mixture extracted much more potassium from blood than benzene, ether and chloroform, the behaviour of which was typical of the other solvents studied.

It was necessary to rule out the possibility that the results in Table 1 could be ascribed to the solubility of the inorganic salts of potassium-42 directly in the chloroform–methanol mixture. For this purpose, an additional step was added to the procedure. The filtered chloroform–methanol extract was evaporated to dryness. The dry material was then taken up in chloroform (which had been dried over calcium chloride), filtered, transferred to a counting planchet and dried once more. The potassium content in the final chloroform solution was calculated as millmoles potassium in chloroform solution per litre of material extracted. From Table 1 it can be seen that chloroform by itself extracts only a negligible quantity of potassium-42 from blood. To confirm this point, the usual inorganic buffer solution used in potassium transport studies (ref. 6, Table 1), which simulates the ionic composition of plasma, was dried and subjected to the extraction procedure described above. The potassium uptake (uptake is used in the special sense of cation solubility in chloroform) was 0·0008 m.mole/l. buffer, which is to be compared to values of 0·532 m.mole/l. blood, and 0·221 m.mole/l. plasma when blood and plasma were extracted under the same conditions. From these results it was concluded that a material capable of carrying cations into non-polar solvents, such as chloroform, could be extracted from plasma and blood.

The uptake of potassium by plasma extracts was compared with that of sodium. The potassium ion concentration in plasma was raised to an average of 11·9 m.moles/l. plasma by the addition of the potassium-42; the sodium concentration was 144·0 m.moles/l. plasma. In ten experiments, the average potassium uptake was 2·51 ± 0·62 μmoles/gm. dried plasma; and in six experiments, the average sodium uptake was 11·28 ± 2·24 μmoles/gm. dried plasma. If the uptake is directly proportional to plasma cation concentration, it would be expected that the sodium uptake would be 12·1 times greater than the potassium. The fact that the observed uptake was only 4·5 times greater suggests that the extracted material discriminates between these two cations, potassium being taken up in preference to sodium. The difference in uptake between the cations is expressed in terms of a potassium/sodium competition factor which is defined as (K uptake/Na uptake)/([K]/[Na]) and is equal to 2·7 in this case. If there are saturation effects, a more complex expression will be required.

Experiments were next carried out to see whether the chloroform-soluble material would give up the extracted cation to water. For this purpose, a volume of chloroform extract was shaken with an equal volume of water for 10 min. At the end of this period, 31 per cent of the activity was found in the water solution. The water solution was then shaken again for 10 min. with an equal volume of fresh chloroform, and no potassium-42 was taken up by the chloroform. Thus the material initially responsible for taking potassium ions into the chloroform solution is no longer present in the water phase, and has apparently dissociated, releasing its potassium to the water phase.

Studies were also initiated to determine the extent to which purified lipides might possess the power to combine selectively with sodium and potassium ions. Lipide samples (for which we are indebted to Drs. Manfred L. Karnovsky, Jordi Folch-Pi, Gerhardt Schmidt and James Garvin) were emulsified with buffer solution (sodium chloride and potassium chloride concentrations modified as shown in Table 2) and incubated separately with sodium-24 and potassium-42 ions. The results of these experiments are presented in Table 2. It will be seen that sphingomyelin, phosphatidyl-serine and acetal phosphatide showed characteristic uptakes of sodium and potassium, potassium being taken up preferentially (see Table 2, col. 6). Cholesterol, which has no phosphate or other charged groups, was ineffective in taking potassium and sodium into solution.

Table 2. Uptake of Potassium and Sodium in Chloroform Extracts of Purified Lipides

Lipide	Concentration (m.mole/l.)		Uptake m.mole/m.mole lipide		K/Na competition factor
	Potassium	Sodium	Potassium	Sodium	
Phosphatidyl-serine	4·28	132·8	0·664	1·50	14·2
Sphingomyelin	4·64	132·8	0·645	2·57	7·5
Acetal phosphatide	4·28	132·8	0·386	1·40	8·9
Cholesterol	2·4	64·0	0·005	0·02	6·7

The problem of cation binding has been approached in the present study specifically with the intention of finding a material suitable for transporting cations across the red-cell membrane, and thus of giving support to the carrier theory of ion transport. In this respect, it now appears that a heterogeneous material can be extracted from blood that has the requisite characteristics, namely: (1) it can discriminate between sodium and potassium ions, preference being given to the latter; (2) it is soluble in lipide solvents; and (3) it dissociates in water. It seems likely that the material is lipide in character and possibly contains phosphatides. Whether the material plays a part in cation transport has yet to be established, and experiments covering this aspect of the problem are now in progress.

The present studies have been supported in part by the Atomic Energy Commission. We wish to thank Drs. F. R. N. Gurd, Oscar Hechter, M. L. Karnovsky and F. M. Snell for many stimulating and informative discussions during the course of these experiments.

[1] Christensen, H. N., and Hastings, A. B., *J. Biol Chem.*, **136**, 387 (1940).
[2] Folch, J., "Psychiatric Research", 24 (Harvard Univ. Press, Cambridge, Mass., 1948).
[3] Baer, E., Buchnea, D., and Newcombe, A. G., *J. Amer. Chem. Soc.*, **78**, 232 (1956).
[4] Christensen, H. N., *Science*, **122**, 1087 (1955).
[5] Steinbach, H. B., "Nerve Impulse, Transactions of the Second Josiah Macy Conference", 15 (ed. D. Nachmansohn, Josiah Macy Foundation, New York, 1951).
[6] Solomon, A. K., *J. Gen. Physiol.*, **36**, 57 (1952).
[7] Folch, J., Ascoli, I., Lees, M., Meath, J. A., and LeBaron, F. N., *J. Biol. Chem.*, **191**, 833 (1951).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Observation of Magnetic Domains in Electron Shadow Photographs

During a study of the magnetic effects produced on a fine electron beam by an unmagnetized single crystal of hexagonal cobalt, an effect was found which shows the existence of domains in a particularly vivid manner.

A small aperture of 12μ close to the crystal surface is used to limit the electron beam of a conventional electron diffraction apparatus. This aperture produces, in addition to the main beam, a diffuse electron beam which gives a magnified shadow photograph of the crystal on the photographic plate (Fig. 1). The electron beam is almost parallel to the prism face of the crystal, the direction of the beam being nearly parallel to the hexagonal axis. The horizontal edge of the crystal, appearing in the photograph as a succession of small cusps, is normal to the hexagonal axis and forms part of the prism face. This face is nearly normal to the plane of the photograph. The main beam strikes the crystal surface and does not appear in the photograph.

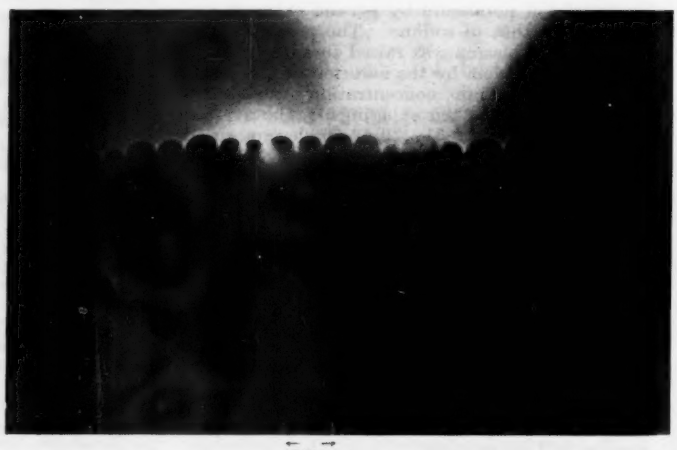
The explanation of these cusps appears to lie in the action on the electrons of the magnetic leakage field near the surface of the cobalt. It is known[1] that at room temperature the domains in hexagonal cobalt have a preferred axis parallel to the hexagonal axis, that the leakage field is very strong close to the hexagonal face (of the order of 10,000 oersteds)[2] and that it dies off to relatively small values at about 40μ [3]. In an investigation of the fields at an edge of the hexagonal face of a cobalt crystal, Marton, Simpson and Lachenbruch[4] find a value of 100 oersteds at about 40μ.

Using the main beam from the aperture as a probe, the magnetic fields leading to the formation of the cusps were investigated. If the effects on the edge of the hexagonal face of the cobalt crystal are studied with electrons of energy 46 keV., it is found that the cusps are formed from electrons passing at a distance between 70μ to 120μ from the edge, where the average value of the magnetic field is of the order of 100 oersteds. Those electrons which pass closer to the edge are deflected by larger amounts and form part of the general background.

The cusp shape must evidently follow from the character of the multipole field produced by oppositely magnetized domains. In order to explain in a simple manner the formation of the cusps at the edge of the hexagonal face, we take a cross-section through the crystal parallel to the hexagonal axis. This cross-section showing the magnetic domains, and the associated leakage field in this plane, are represented diagrammatically in Fig. 2. We first consider the effect of this field on a parallel electron beam of rectangular cross-section, indicated by the shaded area, which cuts the plane of the figure at a certain average distance from the edge. The deflexions of the electrons in the beam on passing through various parts of the field have been indicated by arrows. These deflexions are shown again in the top diagram, which also shows the resultant effect on the beam, that is, the formation of the cusps. In particular, it will be seen that the distance between successive cusp tips (a–b, b–c) is equal to the sum of the widths (D) of neighbouring domains of opposite polarity; this sum (L) we will term 'domain spacing'. Instead of the parallel beam, we can now consider a part of the divergent beam produced by the small aperture, this part having the same cross-section as the parallel beam. Similar cusps will be produced, which will appear highly magnified if photographed at a distance which is large compared with the distance between the aperture and the edge of the crystal.

We next consider the case in which a beam, of the same cross-section as before, is approximately parallel to a prism face and in the direction of the hexagonal axis (as in Fig. 1). The leakage field responsible for the formation of the cusps in this case is produced by the same domains as in the previous case. We consider the field in a plane situated close to the edge and at right-angles to the plane of Fig. 2, if this is taken to be the prism face; it has approximately the same form as the field represented in this figure. A similar analysis again shows that the electron beam is distorted into a succession of cusps. The cusps are observed in both cases discussed, and in other cases in which the beam is not parallel to the hexagonal axis. The illustration (Fig. 1) was chosen because it shows in addition a corner of the crystal.

Measurements of 'domain spacing' have been made in the two cases mentioned above. The magnitude of the 'domain spacing' varies from 40μ to 240μ, the most frequent value lying between 100μ and 160μ. Values of the 'domain spacing' found from published photographs of Bitter figures on the prism face of hexagonal cobalt[1] vary from 40μ to 170μ, which are similar to those found in our experiments.



200μ

Fig. 1. Shadow photograph of an unmagnetized crystal of hexagonal cobalt, showing domain effects

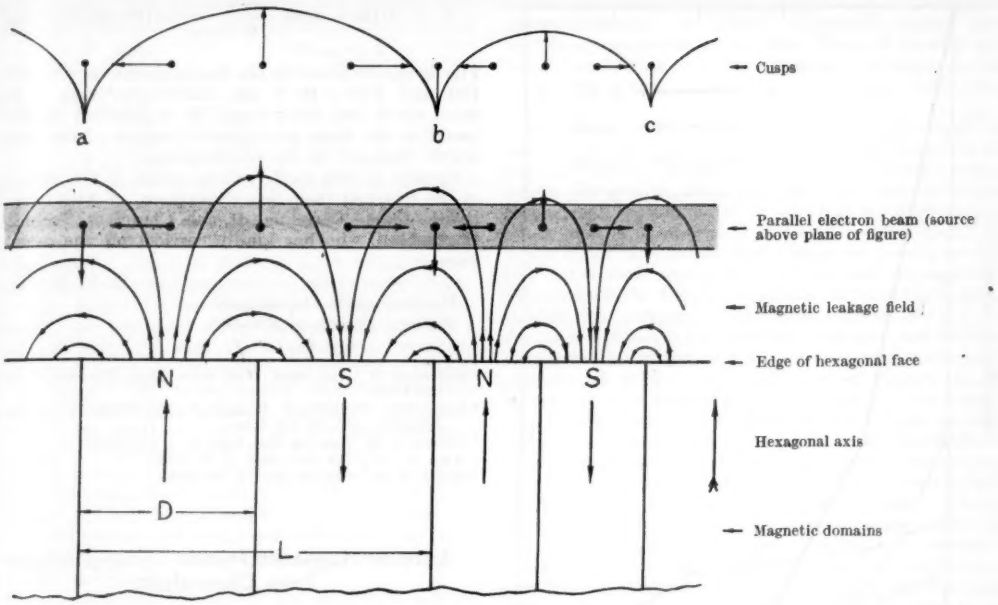


Fig. 2. Illustration of the formation of cusps

A detailed account of these and other magnetic effects will be published shortly. We are indebted to Dr. R. S. Tebble and Prof. E. C. Stoner, of the University of Leeds, for the cobalt crystals. One of us (E. G.) is indebted to the British Council for a scholarship and grant, which have enabled him to take part in this research.

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[1] Elmore, W. C., *Phys. Rev.*, **53**, 757 (1938).
[2] Germer, L. H., *Phys. Rev.*, **62**, 295 (1942).
[3] Scheidler, G., Arbeitstagung Festkörperphysik, 181 (Dresden, 1954).
[4] Marton, L., Simpson, J. A., and Lachenbruch, S. H., *J. Res. Nat. Bur. Stand.*, **52**, 97 (1954).

Vertical Eddy Diffusion in Deep Water

The equilibrium of the uranium series in sea water is interrupted by the removal of ionium (thorium-230)[1]. The efficiency of the removal seems, according to investigations by Koczy, Picciotto, Poulaert and Wilgain[2], to be higher than 98 per cent. This means that the ionium in solution is almost completely precipitated, and the radium content of sea water must be renewed from radium produced in the sea floor by the decay of precipitated ionium. The amount of radium supplied to the ocean by river water seems to be only a few per cent of that necessary to keep the radium content of sea water at its average value of 8×10^{-17} gm. per ml. The radium is transported by currents and eddies in the deep water and is moved upwards by eddy-diffusion. The distribution of the radium in the deep water should, therefore, enable the eddy diffusion to be estimated.

As a first approximation, it is assumed that the sea floor delivers per square metre and year the same amount of radium throughout a large region of the deep sea floor, that the advection is zero, and that the distribution of radium is stationary. Then, if the decay of the radium during its transport is also taken into consideration, the following equation is obtained:

$$\frac{\partial}{\partial t}\left(\frac{A}{\rho}\frac{\partial c}{\partial t}\right) - \lambda c = 0$$

where c is the radium content, λ is the decay constant of radium and t is the height above the bottom or the zero-level. This equation solved in respect to A gives:

$$A(\xi) = A(0)\left(\frac{\partial c}{\partial t}\right)_{t=0} \Big/ \left(\frac{\partial c}{\partial t}\right)_{t=\xi} + \lambda\rho \int_0^{\xi} c\,(t)\,dt \Big/ \left(\frac{\partial c}{\partial t}\right)_{t=\xi}$$

In order to estimate the variation of $A(\xi)$ with depth, the eddy-diffusion at a reference-level must be known. This may be obtained if it is assumed that the eddy diffusivity in the thermocline is near zero; moreover, the eddy diffusivity must not show negative values. The derivatives are read from the smoothed curve of the distribution of radium with depth, and the integral value is also obtained by graphical evaluation.

During the Swedish Deep-Sea Expedition (1947–48), a series of radium determinations was carried out[3]. This series demonstrates that the radium content in the ocean is generally lowest at the surface and rapidly increases in deep water with decreasing stability. At two stations in the Atlantic, the distribution of radium with depth shows a more complex structure. This may be explained by the existence of the North

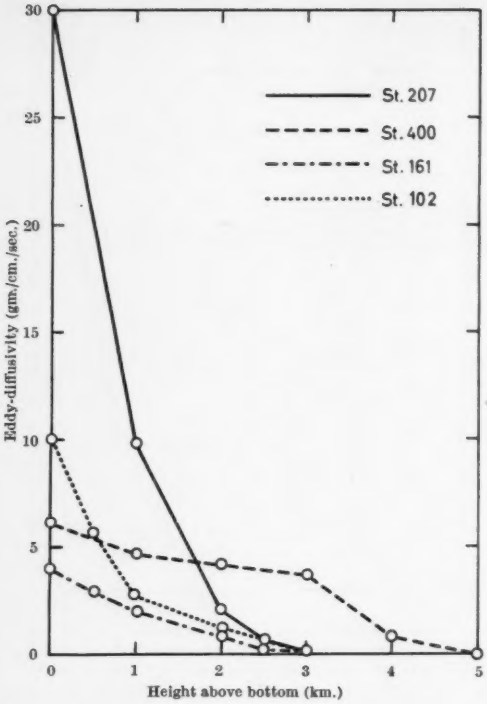

Fig. 1

Atlantic water, whereas a corresponding water mass originating in the Arctic region is absent from the other oceans. The distribution of radium in the deepest layer of the Mindanao Trench does not conform with the general pattern. For our calculations four stations were selected, one in the Atlantic, one in the Indian Ocean and two in the Pacific Ocean. Their geographical position and the total depth are as follow :

	Lat.	Long.	Depth
Station 102	13° 25′ S.	149° 30′ W.	4,630 m.
161	5° 10′ N.	127° 53′ E.	8,200
207	0° 01′ S.	88° 18′ E.	4,486
400	43° 04′ N.	19° 40′ W.	5,990

As zero-level the depth of the deepest-water sample was generally taken at a distance of about one hundred metres above the sea floor. But at Station 161 in the Mindanao Trench the mean depth of the Pacific Ocean was chosen as zero-level. The results from the calculation are given in Fig. 1.

The eddy-diffusivity near the bottom varies between 4 and 30 c.g.s. units and decreases with distance from the sea floor. The values obtained by this method are not as high as the values obtained by Wüst[4] from a dynamical calculation. One reason for this may be that the variance of the eddy-diffusivity is so high that values of 70 c.g.s. may also be obtained in certain places by our method. On the other hand, the eddy-diffusivity should always be lower than the eddy-viscosity. It must be pointed out that the lowest values of the eddy-viscosity are about a power of ten higher than our lowest value for the eddy-diffusivity.

The amount of radium given off from 1 sq.m. of the sea floor per year is given by :

$$\varphi = 3{\cdot}16 \times A(0) \left(\frac{\partial c}{\partial t}\right)_{t=0} \times 10^{11} \text{ gm./m.}^2\text{/year}$$

The figures obtained at the four stations vary between 120 and 180 $\times 10^{-12}$ gm. radium/m.²/year. The same result has been found by a different method[5] based on the total geochemical balance of the radioactive elements in the hydrosphere.

Details of this work will be given in the Reports of the Swedish Deep-Sea Expedition. I wish here to thank Östen Carlsson, of the Chalmers Technical Highschool, who has kindly carried out the calculations.

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[1] Pettersson, H., *Anz. Akad. Wiss. Wien, Math. Naturwiss. Klasse*, 127 (1937).
[2] Koczy, F. F., Picciotto, E., Poulaert, J., and Wilgain, S., *Geochim. et Astrochim. Acta* (in the press).
[3] Pettersson, H., *Deep-Sea Res.*, supp. to 2, 373 (1955).
[4] Wüst, G., *Deep-Sea Res.*, supp. to 3 (1955).
[5] Koczy, F. F., *Deep-Sea Res.*, 3, 93 (1956).

Lattice Magnetostriction in Spinel-Type Iron Chromites

Several accounts have previously been given from these Laboratories of the lattice dilatation effects that occur when monoxides and other compounds of the transition metals are cooled through their paramagnetic–antiferromagnetic transition temperatures.

Two instances of structural deformations at low temperatures in spinel-type oxides have also been reported. Thus Tombs and Rooksby[1], using X-ray powder methods, showed that in magnetite (Fe_3O_4) a rhombohedral deformation takes place below − 160° C., and Rooksby and Willis[2] found that at − 180° C. the structure of cobalt ferrite is tetragonally deformed. The rhombohedral nature of the magnetite structural change was later critically investigated by Abrahams and Calhoun[3] by magneto-X-ray single-crystal methods. Although they found some fine detail not detected in the powder work, and suggested that the true low-temperature structure is of orthorhombic or lower symmetry, the rhombohedral interpretation appears to be valid to a first approximation[4].

Besides the observations of distortions in such sodium chloride-type and spinel-type structures, measurements on ferric oxide[5] and chromium oxide[6] have disclosed lattice dilatations associated with antiferromagnetic transitions. Consequently there seemed to be grounds for predicting that lattice magnetostrictive effects similar to those already observed in in Fe_3O_4 and $CoFe_2O_4$ might occur at low temperatures in chromium-substituted cubic iron oxides, that is, in solid solutions of the general form $FeFe_{2-x}Cr_xO_4$. Confirmation of this prediction has recently been obtained by X-ray powder studies of several such iron oxide/chromite preparations, using liquid air-cooling and gas-cooling techniques.

When observations are made at − 180° C., for compositions in which the value of x in the solid solution lies between 0·2 and 0·8 the structural deformation established as characteristic of Fe_3O_4 becomes vanishingly small. At $x = 1{\cdot}0$, however, a new tetragonal-type distortion becomes evident at liquid-air temperature, and for $x = 1{\cdot}2$ the

Table 1. X-RAY DATA FOR IRON OXIDE – IRON CHROMITE SOLID SOLUTIONS OF COMPOSITION $FeFe_{(2-x)}Cr_xO_4$

Composition x	Cubic at 20° C.		Tetragonal at − 180° C.	
	a_0 (A.)	a_0 (A.)	c_0 (A.)	c/a
1·0	8·396	8·384	8·392	1·001
1·2	8·405	8·369	8·410	1·005
2·0	8·377 (± 0·001)	8·454	8·187	0·968

magnitude of this distortion has increased appreciably, as shown in Table 1.

The results obtained for the solid solutions led us to believe that with pure ferrous chromite, $FeCr_2O_4$, an even larger lattice dilatation effect might be obtained at liquid-air temperature. Examination disclosed that, although the tetragonal deformation was indeed larger in magnitude, there was a change in its sense. The tetragonality observed was the result of a relative contraction, instead of expansion, in one of the [001] directions, so that the axial ratio was less, not greater, than 1·0 (see Table 1).

It will clearly be of considerable interest to examine the low-temperature behaviour of compositions between $x = 1·2$ and $x = 2·0$. X-ray studies are now being carried out on several solid solutions lying in this range, and it is hoped to present all the results in detail elsewhere.

The mechanism by which the structure cell of spinel-type oxides of this type deforms from its room-temperature cubic symmetry on cooling through a certain critical temperature is not yet properly understood. It would appear likely, however, that the lattice dilatation effects are linked with alterations of the magnetic dipole alignments such as have been discussed by Li[7] in connexion with simple antiferromagnetic monoxides and other compounds. It is possible that an extension of Li's arguments on spontaneous magnetostriction to the spinel-type compounds will explain all the various structure changes that have been described above.

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[1] Tombs, N. C., and Rooksby, H. P., *Acta Cryst.*, **4**, 474 (1951).
[2] Rooksby, H. P., and Willis, B. T. M., *Nature*, **172**, 1054 (1953).
[3] Abrahams, S. C., and Calhoun, B. A., *Acta Cryst.*, **8**, 257 (1955).
[4] Rooksby, H. P., and Willis, B. T. M., *Acta Cryst.*, **6**, 565 (1953).
[5] Willis, B. T. M., and Rooksby, H. P., *Proc. Phys. Soc.*, **65**, 950 (1952).
[6] Greenwald, S., *Nature*, **177**, 286 (1956).
[7] Li, Y. Y., *Phys. Rev.*, **100**, 627 (1955).

Ductility in Chromium

MUCH recent work has been carried out on the preparation and properties of pure chromium with the aim of establishing chromium base alloys as engineering materials. The obstacle to this, the room-temperature brittleness, has naturally attracted great attention. It has been suggested that the brittleness of chromium is promoted by nitrogen content above 20 p.p.m., by rough surface condition and by recrystallization. It had been found previously that the greatest lowering of the ductile/brittle transition temperature in chromium is obtained in polished pieces which have been worked below the recrystallization temperature. Complete recrystallization in rolled chromium raises the transition temperature so that there is usually no bend ductility at room temperature, although pieces in this condition showing ductility have been produced[1].

Recently, we have found that the main source of nitrogen in electrolytic chromium is the presence of nitrates in the electrolyte of a conventional hexavalent chromium bath and that nitrogen in other forms such as ammonia or air has no appreciable effect on the composition of the deposited metal.

We have also found that chromium produced by the lubricated extrusion of sheathed, compacted flakes can show ductile behaviour in bend tests, even though the nitrogen content is as high as 900 p.p.m. An electro-polished piece made in this way, and having an insoluble content of 1·25 per cent and a nitrogen content of 0·091 per cent, showed ductile bend behaviour at a temperature of − 30° C., but broke in a brittle manner at − 50° C. Charpy-type impact tests on a low-nitrogen piece of this extruded chromium gave results of 2·17 ft.lb. at room temperature and 5·74 ft.lb. at 250° C. using machined, unnotched specimens of 1 cm. square cross-section. These figures can be compared with corresponding values of 0·4 and 0·6 ft.lb. respectively for tests on similar-sized chromium bars made by sintering chromium powder in purified hydrogen. X-ray diffraction examination of the extruded chromium showed it to be in a fully recrystallized condition.

It therefore appears that the extrusion method indicated above has an effect of increasing ductility and lowering of the transition temperature which over-rides the opposing effect of nitrogen content and recrystallization. Clearly a measure of preferred orientation may be produced by the extrusion and this may be playing an important part in the effect. This is being investigated.

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[1] Wain, H. L., Henderson, F., and Johnstone, S. T. M., *J. Inst. Met.*, **83**, 133 (1954–55).

Application of the Schlieren Technique to the Study of Ripples

IN the simplest form of ripple tank demonstration, a 'point' source of light placed below the tank is used for casting 'shadows' of the ripples on a screen. The ripples have a complicated lens action on the light, so that the relation between the pattern of ripples on the water surface and the pattern of light and shade on the screen is not necessarily a simple one: caution must be exercised in interpreting the finer details of the pattern observed. In more complicated forms of the apparatus, a lens is used above the tank for projecting on to the screen a real image of the ripples; but the same difficulty arises. If the water surface is in sharp focus, the ripples are almost invisible. The lens must be raised so that it focuses the focal lines of light produced by the ripple crests. Now the distance of these focal lines above the surface of

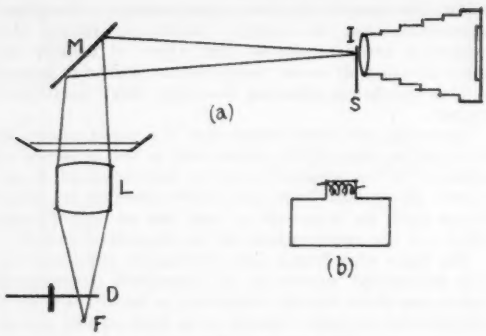

Fig. 1

the water depends on the curvature of the ripples, and since this varies with the attenuation of the waves, it is impossible for the pattern to be in sharp focus over the screen, while obstacles introduced into the tank to produce reflexion, refraction or diffraction are always out of focus.

The schlieren technique, normally used for revealing regions of varying refractive index in a gas, appears to offer a solution of the problem. In the arrangement (Fig. 1) used for obtaining the accompanying photographs, an epidiascope lens L of 4 in. aperture was mounted, with axis vertical, immediately below the tank. The source was a micro-projector lamp, F (30-W., filament size 3 mm. × 2 mm.), placed so that the lens focused its light through the tank to form a real image 9 mm. × 6 mm. For convenience, the axis of the beam is made horizontal by the surface-silvered mirror M. The image of the filament is thus focused at I in front of the camera lens and the camera itself is focused on the surface of the water. The image I is intercepted by the screen S. (The shape of S, with image I superimposed, is shown at Fig. 1*b*.) The field of view on the camera screen thus becomes uniformly dark. Any disturbance on the surface of the water which deflects light upwards or sideways will appear bright on the screen and the ripples are thus made visible. The lens of the camera should be used at full aperture, with the shutter open, and an exposure made by uncovering F.

The photographs (Fig. 2) show: (*a*) partial reflexion, refraction and interference of linear waves originating in deep water and impinging on the apex of a triangular patch of shallow water; (*b*) passage of waves from shallow into deeper water, with total internal reflexion and interference; (*c*) interference of light from two point sources.

The ripples were produced by a vibrator driven from 50 ~ supply, and a stroboscopic disk was used at D. The exposure was about $\frac{1}{4}$ sec. Work is now in progress on ciné-photography of the ripples.

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X-Ray Hazard in Sputtering Apparatus

In a paper to be published in the *Proceedings of the Physical Society* on the "Bombardment of Various Elements by Hg^+ and A^+ Ions", we have described sputtering experiments with low-pressure gas discharge tubes where an appreciable intensity of X-radiation was observed. It has been pointed out to us that, whereas the hazards of X-rays in magnetrons[1], gas-filled[2] and vacuum valves are well known, the indirect production of X-rays during sputtering at high voltages would be generally unsuspected, and that the matter should be given wider mention.

The discharge tubes used in these experiments had each an oxide-coated flat nickel-strip cathode and an 'Armco' iron anode. The discharges were formed in argon or mercury vapour at currents ranging from 0·1 to 15 amp., with a cathode-to-anode voltage drop of about 20 V. The targets were attached to side arms sealed to the discharge tubes and were exposed to the discharge plasma. Negative potentials of up to 20 kV. were applied to the targets so that they were bombarded by positive ions drawn from the discharge. The target currents depended on the experimental conditions and ranged from 0·1 to 10 m.amp. With the various targets studied, including carbon, iron and uranium, copious secondary electron emission by positive ion bombardment was found at the higher voltages. The X-rays observed were shown to arise from the acceleration of these electrons across the positive ion sheath surrounding the target and their subsequent collision with the walls of the discharge tube. At 8 kV. and above, the X-rays were detected by the fogging, within an hour or so, of Ilford dental X-ray film placed about six inches from the tube, indicating radiation intensities at that point of roughly 10^{-5} r./sec., which exceeds the maximum permissible dose-rate.

Thus in similar experiments or industrial processes involving ion bombardment at, say, 10 kV. and

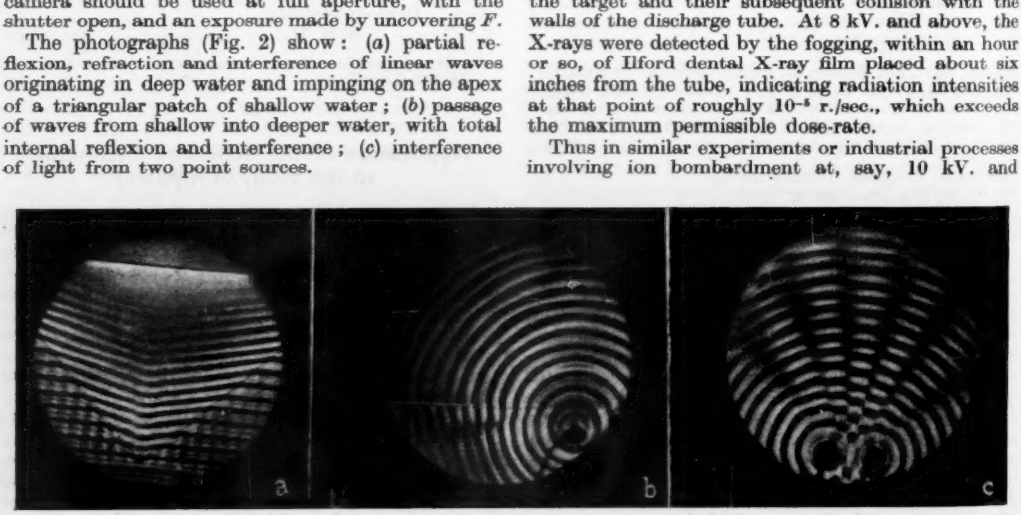

Fig. 2

above, it is essential to test for X-rays, and to shield against them if they present a hazard to personnel.

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[1] Dunsmuir, R., Milner, C. J., and Spayne, A. J., *Nature*, **161**, 244 (1948).
[2] Schneider, S., and Reich, B., *Proc. Inst. Rad. Eng.*, **43**, 711 (1955).

Existence of a Non-Electrostatic Stabilizing Factor in Hydrophobic Selenium Hydrosols

It is well known that the stability factor of hydrophobic sols decreases, at first, exponentially with the ionic strength of the solution, and reaches, rather suddenly, its limiting value for a certain concentration C_1 of the coagulating electrolyte[1]. For concentrations lower than C_1 we have the so-called 'slow coagulation'; the interaction energy consists of long-range electrical repulsions, dependent on ionic strength, and of Van der Waals attractions. For concentrations higher than C_1, the electrical repulsions have practically disappeared[2] and we have 'rapid coagulation'.

The kinetics of rapid coagulation have been studied theoretically. Each particle is assumed to be surrounded by a sphere of attraction having a radius r. If the centre of a second particle penetrates into this sphere of attraction, the two coalesce irreversibly. Treating the problem as one of simple diffusion, von Smoluchowski[3] showed that the disappearance of primary particles must initially be a bimolecular process, characterized by a kinetic constant:

$$k_{1\cdot1} = \frac{4kT}{3\eta} \cdot \frac{r}{a}$$

where k is Boltzmann constant, T is the absolute temperature, η is the viscosity of the medium and a is the radius of the particles.

The ratio r/a must obviously have a value of at least 2, and Hamaker[4] has shown that it should be slightly larger. Experimental values between 2 and 3 have been found in a number of cases.

However, for selenium hydrosols, Kruyt and Van Arkel[5] found very small values ranging from 0·55 to 1·3. With sols prepared in a similar manner, we have confirmed their results, obtaining values between 0·58 and 1·06, as shown in Table 1. It therefore appears that for selenium sols, some repulsive force unconnected with the charge of the double layer must be taken into account.

We have found that the abnormal stability is due to an impurity, probably hydrazine hydrate, which is used as a reducing agent for preparing the sols.

Table 1. Experimental Values for the Ratio r/a, with Non-dialysed Selenium Hydrosols

Sol concentration (No. of particles/cm.³)	Diameter of particles (mμ)	r/a
0·62 × 10¹⁹	188	1·06
0·96	168	0·84
3·14	142	0·58
1·57	142	0·62
0·78	142	0·77

Table 2. Variation of the Ratio r/a during Purification of a Selenium Hydrosol

Time of electrodialysis (hr.)	Conductivity of the sol (ohm⁻¹ cm.⁻¹)	r/a
0	133·0 × 10⁻⁶	1·5
22·5	118·0	1·8
29·75	95·5	2·1
46·0	57·0	2·3
71·0	8·8	2·2
78·5	8·0	(3·9)
118·5	6·5	2·1
167·0	4·2	2·2

The numerical data given in Table 2 show clearly that when the colloidal solutions are purified by prolonged electrodialysis, the ratio r/a increases regularly with the purity, as measured by specific conductivity.

In another series, r/a varied from 0·44 to 2·5 during purification.

It must be stressed that the purification has practically no influence on the stability factor in the region of slow coagulation, or on the limiting concentration C_1. Therefore, it does not affect the Stern potential.

A tentative explanation of this behaviour is that each micelle is covered by an adsorbed layer of hydrazine, and this strongly polar substance modifies the local structure of water in the immediate neighbourhood of the colloidal particle. The 'hydration' shell may cause a repulsive action of entropic origin—a steric hindrance.

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[1] Reerink, H., and Overbeek, J. T. G., *Disc. Farad. Soc.*, **18**, 74 (1954).
[2] Verwey, E. J. W., and Overbeek, J. T. G., "Theory of the Stability of Lyophobic Colloids" (Elsevier, 1948).
[3] Von Smoluchowski, M., *Phys. Z.*, **17**, 557, 585 (1916); *Z. phys. Chem.*, **92**, 129 (1918).
[4] Hamaker, H. C., *Physica*, **4**, 1058 (1937).
[5] Kruyt, H. R., and Van Arkel, A. E., *Rec. Trav. Chim.*, **39**, 656 (1920); **40**, 169 (1921).

Synthesis of 4-Methylumbelliferone β-D-Glucuronide, a Substrate for the Fluorimetric Assay of β-Glucuronidase

At the present time there is considerable demand for a suitable synthetic substrate for the routine assay of β-glucuronidase. The most common assay method employs phenolphthalein glucuronide isolated from rabbit urine[1]. However, the preparation of 4-methylumbelliferone glucuronide from rabbit urine and its use in the fluorimetric assay of β-glucuronidase have been recently described[2]. This substrate promises certain advantages over phenolphthalein glucuronide, and it is easy to synthesize by the method previously employed for (−)-menthol[3] and phenol[4] β-D-glucuronides.

4-Methylumbelliferone β-D-glucoside hemihydrate[5] (1·5 gm.) in 60 ml. water was maintained at 90° C. and vigorously stirred. Oxygen was passed into the solution through a sintered glass disk, and freshly reduced platinum catalyst[3] (0·4 gm.) was added. The *p*H was kept between 7 and 9 throughout the oxidation by the addition of 0·5 *N* sodium bicarb-

onate. After 1 hr., more catalyst (0·2 gm.) was added, and the reaction was complete 30 min. later, with an almost theoretical uptake of alkali. The filtered solution was reduced to half volume, treated with charcoal, and made acid to congo red with hydrochloric acid. The hydrated glucuronide was filtered off and recrystallized from 50 per cent (v/v) aqueous ethanol and then from water: yield 0·95 gm. (54 per cent). After drying at 105° over phosphorus pentoxide, the hemihydrate[2] had corrected and mixed melting points with a biosynthetic specimen of 139–140°, and $[\alpha]_D^{23}$ −119° in water (*c*, 0·25): on acid hydrolysis 4-methylumbelliferone was obtained, melting point and mixed melting point 187–188°. Mead *et al.*[2] give a melting point of 139–140° (decomp.) for the hemihydrate of the biosynthetic glucuronide, and $[\alpha]_D^{23}$ −105° for the completely hydrated compound.

Grateful acknowledgment is made to Prof. R. T. Williams and Dr. D. Robinson for specimens and unpublished results.

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[1] di Somma, A. A., *J. Biol. Chem.*, 133, 277 (1940).
[2] Mead, J. A. R., Smith, J. N., and Williams, R. T., *Biochem. J.*, 61, 569 (1955).
[3] Marsh, C. A., *J. Chem. Soc.*, 1578 (1952).
[4] Tsou, K.-C., and Seligman, A. M., *J. Amer. Chem. Soc.*, 75, 1042 (1953).
[5] Robinson, D., and Williams, R. T., *Biochem. J.*, 61, v (1955).

Phase-Change in 1,2,4,5-Tetrabromobenzene investigated by Pure Quadrupole Resonance

It is the purpose of this communication to mention a result of a type which we believe to be hitherto unreported, which we obtained when the temperature dependence of the bromine-81 pure quadrupole resonance at about 240 Mc./s. in 1,2,4,5-tetrabromobenzene was investigated. Here, on raising the temperature above 20° C., there is as usual a linear decrease of frequency. However, a very sudden discrete drop occurs at 46·5° C., after which there is again a linear decrease. On then reducing the temperature, the increase of frequency is linear as far as 33·5° C., where there is a sudden discrete rise, the frequency returning to the original line and completing a hysteresis loop.

The experimental results are shown in Fig. 1. The temperature coefficients of frequency are $-3{\cdot}9 \times 10^{-5}$/deg. C. and $-5{\cdot}9 \times 10^{-5}$/deg. C. for the upper and lower straight line portions respectively. The frequency jump is of the order of 1·5 parts in 10^3. It is interesting to note that the temperature coefficient at temperatures above the discontinuity is of the order usually found in compounds where bromine is attached to the benzene ring, while that at temperatures immediately below is about 35 per cent lower.

The resonance was obtained by means of an externally quenched frequency-modulated super-regenerative oscillator using a cathode-ray oscillograph display. A push–pull arrangement was used employing type 955 'acorn' triodes, the sample being placed in a tuned coil at the far end of the anode lines. A simple oven surrounds the specimen. Comparison between frequency measurements made with slowly rising and slowly falling temperatures indicates that the error of temperature measurement is ± 0·2° C.

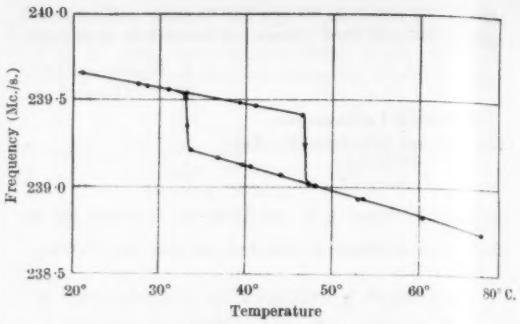

Fig. 1. Frequency of bromine-81 pure quadrupole resonance in 1,2,4,5-tetrabromobenzene as a function of temperature

Frequency measurements were made by adjusting the amplitude and frequency of quench so that the resonance appeared as a single peak. This was then located at the centre of the cathode-ray oscillograph display. The sweep and quench were then switched off, and the frequency of the oscillator measured by obtaining zero beat with a harmonic of a calibrated wave-meter, type *BC*-221-*C*, detected by means of a G.E.C. very high frequency panoramic receiver, type *BRT*-652. The calibration of the wave-meter was set for each reading by means of the 2 Mc./s. crystal incorporated in the receiver. This was, in turn, checked against a B.B.C. transmission at 94·3 Mc./s., which afforded a sufficiently accurate standard at a convenient frequency. This system of measurement gives an error of about ± 5 parts in 10^5, which includes that of setting the oscillator exactly upon the quadrupole frequency.

Thanks are due to Mr. D. Pardy for carrying out the measurements.

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Factors affecting the Permanency of Paper: Tests with Labelled Sulphur

Papers of good quality and high alpha-cellulose content can be kept under suitable storage conditions for several centuries. There are, however, differences of opinion on factors affecting storage, and a recent investigation by Langwell[1–5] claims that even good-quality papers can become brittle at the edges. He stated that this attacked portion of the paper in old documents and books has a scorched appearance resembling the product of the reaction between cellulose and strong acid. Analyses of these old papers reveals a high sulphate content indicative of attack by sulphuric acid from the atmosphere.

The concentration of sulphur dioxide in industrial atmospheres is of the order of 0·5 part per million[6], and Langwell has suggested that catalysts in the paper accelerate the conversion of this sulphur

dioxide to sulphuric acid. By exposing paper, usually under damp conditions, to atmospheres containing about 0·5 per cent sulphur dioxide, that is, 10,000 times that in an industrial atmosphere, Langwell measured the increase in sulphate in the paper by extraction with water and precipitation as barium sulphate. The uptake of sulphur was correlated with catalysts present in, or added to, the paper, and iron was found to be an important catalyst for the conversion of sulphur dioxide to sulphate under these conditions.

His work was limited by the sensitivity of the precipitation method. One of us had found, in another connexion[7], that sulphur-35 could be used very effectively in paper for studying migration by autoradiographs or counting. We therefore decided to repeat some of Langwell's experiments using sulphur labelled with sulphur-35. W. H. Langwell, himself, kindly supplied us with the same papers that he had used in studying the effect of catalyst inhibitors[4].

Detailed results will be published elsewhere, when they are complete, but some new information has been found already. Using a wet atmosphere and 0·5 per cent sulphur dioxide the uptake of sulphur dioxide could be detected with a Geiger–Müller counter after 2-hr. exposure only, and after 24-hr. exposure the papers tested could be shown to fall in general into the order already found by Langwell using a seven-day exposure.

Some labelled sulphur was burned in a desiccator to give a concentration of 1 per cent sulphur dioxide under normal dry conditions (about 50 per cent relative humidity). When papers were exposed to this the uptake of sulphur dioxide could be detected in 3 hr., and after 24 hr. the papers again fell into the order obtained by Langwell.

It was necessary to expose all papers to atmosphere before counting to allow gaseous sulphur dioxide to diffuse out; but a steady counting-rate was obtained after 4 hr.

The labelled paper samples after exposure to sulphur dioxide under both wet and dry conditions were placed between X-ray film for three weeks and then developed. The autoradiographs showed some general take-up of sulphur; but they also showed a random distribution of intense black spots with dark areas spreading from them. The paper itself was now developed with acid potassium ferrocyanide and it was found that the dark areas corresponded to iron, and in some cases, bronze spots in the paper. The take-up of sulphur dioxide is, therefore, partly general and partly localized.

One of us (W. D. M.) holds a George Rackley Scholarship provided by the Northern District of the British Paper and Board Makers' Association.

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[1] Langwell, W. H., *Proc. Tech. Sec. Brit. Paper and Board Makers' Assoc.*, **36**, 199 (1955).
[2] Langwell, W. H., *Tech. Bull. Brit. Paper and Board Makers' Assoc.*, **29**, 21 (1952).
[3] Langwell, W. H., *Tech. Bull. Brit. Paper and Board Makers' Assoc.*, **29**, 52 (1952).
[4] Langwell, W. H., *Tech. Bull. Brit. Paper and Board Makers' Assoc.*, **30**, 170 (1953).
[5] Langwell, W. H., *Tappi*, **38** (9), 190A (1955).
[6] Interim Report on Air Pollution, 18 (H.M.S.O., 1953).
[7] Hudson, F. L., Putnam, J. L., and James, H., *Tappi*, **38** (9), 166A (1955).

Detonation Phenomena in Homogeneous Explosives

In their discussion of certain detonation phenomena in homogeneous explosives, Campbell *et al.*[1] describe a curious effect obtained by lining the container of an explosive with metal foil. They state that very thin metal foils, of the order of 0·001 in. thickness, can reduce quite considerably the diameter at which failure of detonation of nitromethane occurs.

In considering the effect of the container on the detonation of an explosive charge, the natural impulse is to look for an interpretation of the phenomenon in terms of confinement, by which is usually meant the resistance offered by the envelope to the lateral expansion of the detonation products. It is known, however, that the initial mass movement of the products, or 'streaming velocity', is forward, from which it may be deduced that the early stages of detonation are more likely to be influenced by resistance to forward, rather than to lateral, movement. This suggests that frictional resistance at the surface may be a more potent factor initially.

That this effect exists is indicated by the fact that detonation in a gaseous explosive is established sooner in a tube with a rough interior than in one which is smooth. Also, detonation sets in earlier in a narrow tube than in a wide one[2]. These facts show that the onset of detonation is governed by conditions at the surface and that the roughness of the surface is involved. The inference is that frictional resistance at the surface, which is a tangential force and so does not oppose lateral movement, is a significant factor in the development of detonation.

In detonation, very high pressures and velocities are involved and, as violent friction causes abrasion and erosion, the surface material is reduced and is able to mix, and possibly react chemically, with the products of detonation, much as coal dust is raised and consumed in a mine explosion. The violent explosions which have occurred in oil-contaminated compressed-air lines[3], the independent propagation of detonation in tubular cavities in high-explosive cartridges[4], and the low-velocity detonation regime in cartridges of granular explosive[5], are probably further instances of surface films taking part in high-velocity explosive reactions. Thus the action of the surface layer can be chemical as well as physical.

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[1] Campbell, *et al.*, *Nature*, **178**, 38 (1956).
[2] Laffitte, *Ann. Phys.*, **x**, 4, 614 (1925).
[3] Loison, *Rev. l'Ind. Min.*, **34**, 419 (1953).
[4] Woodhead, *Nature*, **160**, 644 (1947).
[5] Jones and Mitchell, *Nature*, **161**, 98 (1948).

Activation of Phospholipid Thromboplastin by Lecithin

This communication is prompted by the recent report of Newlands and Wild[1] that a preparation of soybean phospholipid can serve as a useful source of platelet factor for the thromboplastin generation test. We have been trying in this laboratory for several years to define the phospholipid structures responsible for thromboplastic activity. Reports

have been limited to preliminary communications[2–4] because the degree of purity of the active fractions does not permit a rigorous correlation of structure with activity, although the evidence suggests that the essential structural requirement is the presence of a serine or ethanolamine base in a glycerophospholipid molecule. It should be noted that the activity discussed in this communication is acceleration of the conversion of prothrombin to thrombin in the presence of calcium and a suitable (glass) surface in mammalian coagulation systems. Phosphatidyl serine, which has a higher activity per unit weight than thromboplastic protein in accelerating prothrombin conversion in the rabbit system[2], is without effect when studied with avian plasmas.

The discovery of the activating effect of lecithin arose from two observations. The first was that individual fractions of cephalin, precipitated from methanol according to Maltaner[5], did not show greater activity as their content of amino-nitrogen containing phospholipid increased. The second was that the step in which crude cephalin is precipitated from an ether extract of brain by the addition of ethanol according to the method of Folch[6] led to a loss of 90 per cent of total activity. The activity could be recovered if the fractions were recombined in an organic solvent before the lipid was suspended in aqueous medium for testing. The major component of the less active, ethanol-soluble fraction was lecithin. While the addition of an aqueous suspension of lecithin had no effect, or was at most slightly inhibitory, when added to an aqueous suspension of phospholipid thromboplastin[3], the prior combination of the two in organic solvents had not been tried.

In the present experiments thromboplastic activity was determined as previously described[2]. The source of lipid thromboplastin was a cephalin fraction of beef brain prepared by Maltaner twenty years ago[5] and stored under ethanol. It was as active as fresh preparations, attesting to the exceptional stability of the active component. Analysis of this material showed phosphorus, 3·7 per cent; nitrogen, 1·59 per cent; and serine, 11·4 per cent. Three lecithins were studied: a highly purified egg lecithin, dipalmitoleyl lecithin from yeast and beef heart lecithin (the major component of which was recently shown to be phosphatidal choline, a choline-containing plasmalogen). The lecithins had no thromboplastic activity. The phosphatidyl serine fraction in toluene was combined with a solution of lecithin in toluene. The organic solvent was completely removed under reduced pressure and the lipid suspended in saline. The curves in Fig. 1 show the dependence of clotting time on the logarithm of quantity of cephalin for this preparation of beef brain phosphatidyl serine by itself and in the presence of a two-fold quantity of lecithin. It is apparent that the lecithin–cephalin mixture is ten times as active as the cephalin alone, when comparison is made in the optimal region of the curve (that is, where clotting time reflects most sensitively changes in quantity of active substance and is still sufficiently short to permit sharp endpoints of 50–100 sec.). This represents an increase greater than three-fold based on total weight of combined phospholipids. A smaller activation was obtained when the phosphatidyl serine preparation was combined with either an equal quantity of lecithin or five times the quantity of lecithin, indicating that the activation phenomenon is characterized by optimal proportions and cannot therefore be considered to result entirely from enhanced solubility of

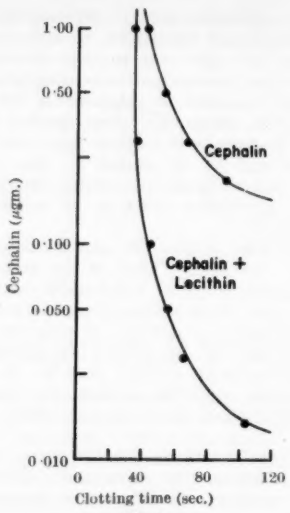

Fig. 1

lipid through mixed micelle formation. A ten-fold quantity of lecithin was inhibitory. It has not been possible to substitute synthetic saturated phosphatidyl ethanolamine or phosphatidyl choline for the natural products, which may be attributed to the difficulty of preparing suitable aqueous suspensions. The phenomenon described here recalls the activation of lipid antigens by lecithin and cholesterol[7], and suggests that the biological properties of phospholipids must be considered in relation to lipid–lipid interactions rather than as discrete functions. Thus, identification of 'active lipid' either associated with protein (for example, thromboplastic lipoprotein, lipoprotein antigens) or free, becomes a much more complex problem. With respect to the substitution of lipid thromboplastin for platelet factor in the thromboplastin generation test, the finding that lecithin activates the thromboplastic properties of cepnalin should permit a product to be formulated with any desired degree of activity, rather than leaving to chance the isolation of suitable material.

I wish to thank Dr. Liselotte Graf, Mr. Nicholas Alonzo and Mr. Bernard Lerner for their co-operation and analytical assistance. I am also indebted to Dr. Donald J. Hanahan for the specimen of dipalmitoleyl lecithin and to Dr. Erich Baer for the synthetic phospholipids.

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[1] Newlands, M. J., and Wild, F., *Nature*, **176**, 885 (1955).
[2] Rapport, M. M., and Maltaner, F., *Fed. Proc.*, **11**, 272 (1952).
[3] Rapport, M. M., and Maltaner, F.. Abstracts of Communication, Second Inter. Cong. Biochem., Paris, 416 (1952).
[4] Rapport, M. M., and Alonzo, N., Abstracts of Papers, Second Inter. Conf. Biochem.: Problems of Lipids, Ghent, 9 (1955).
[5] Maltaner, F., *J. Amer. Chem. Soc.*, **53**, 4019 (1931).
[6] Folch, J., *J. Biol. Chem.*, **146**, 35 (1942).
[7] Pangborn, M., *Trans. Farad. Soc.*, No. 6, 110 (1949).

Isolation of (−) S-Methyl-L-Cysteine from Beans (*Phaseolus vulgaris*)

THE recent isolation[1,2] of S-methyl-L-cysteine sulphoxide from two crucifers, turnips and cabbage, and the chromatographic evidence[3] for its occurrence in many related plants suggested the possibility that methyl cysteine should also occur in plants. In addition, preliminary evidence has clearly indicated that the turnip can readily form the sulphoxide from methyl cysteine. A careful examination[3] of the protein and non-protein fractions of several crucifers revealed no methyl cysteine. Previous work[4] on the non-protein amino-acids of bean seeds showed a ninhydrin-reactive spot which gave an iodoplatinate test[5] indicative of the sulphur amino-acids. This material was found on a two-directional chromatogram (phenol : butanol–acetic acid) in a position corresponding to that of methyl cysteine and close to that of γ-amino-butyric acid. This compound has been isolated and identified as (−) S-methyl-L-cysteine.

Dry kidney bean seeds were ground and extracted with 50 per cent alcohol. The extract was treated with mercuric acetate, and the resultant precipitate was separated and decomposed with hydrogen sulphide. After removal of mercuric sulphide, the solution was passed through a column of sulphonic acid ion exchange resin ('Dowex 50-*X*4') in the acid form and the column was washed. The amino-acids which were retained by the resin were fractionated by displacement chromatography with 0·10 *N* ammonia[6]. The fractions containing the unknown material were contaminated with glutamic acid and asparagine. These three compounds were separated by chromatography on a paper roll[7] using 70 per cent ethanol. The unknown material was purified by three crystallizations from 95 per cent ethanol. Approximately 150 mgm. were obtained from 5 kgm. of beans. The isolate was found to be identical with synthetic (−) S-methyl-L-cysteine with respect to infra-red spectra, optical rotation $[\alpha]_D^{25°} = -26°$ ($c = 2·5$), decomposition point (about 220° C.), and paper chromatography in phenol, butanol–acetic acid and collidine–lutidine ($R_F = 0·71$, 0·27 and 0·38, respectively). The elementary analysis of the isolate was C, 35·6; H, 7·0; N, 10·2; S, 23·5. The calculated values are C, 35·6; H, 6·67; N, 10·37; S, 23·7.

The presence of methyl cysteine in legumes and its sulphoxide in crucifers suggests that these two related compounds may have a widespread occurrence in plants. This possibility, coupled with the preliminary evidence of their interconversion, may foreshadow an interesting metabolic role for the methyl cysteine–methyl cysteine sulphoxide system in plants.

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[1] Morris, C. J., and Thompson, J. F., *Chem. and Indust.*, 951 (1955).
[2] Synge, R. L. M., and Wood, J. C., *Biochem. J.*, **60**, 15 (1955).
[3] Morris, C. J., and Thompson, J. F., *J. Amer. Chem. Soc.*, [**78**, 1605 (1956)].
[4] Zacharius, R. M., Ph.D. thesis (Univ. of Rochester, Rochester, New York), and unpublished data.
[5] Toennies, G., and Kolb, J. J., *Anal. Chem.*, **23**, 823 (1951).
[6] Partridge, S. M., and Westall, R. G., *Biochem. J.*, **44**, 418 (1949).
[7] Hagdahl, L., and Danielsor, C. L., *Nature*, **174**, 1062 (1954).

Malate Synthesis in a Cell-free Extract from a Crassulacean Plant

EXTRACTS of spinach leaves[1] and of wheat germ[2] contain a phosphoenolpyruvic carboxylase which, in the presence of magnesium or manganese ions, catalyses the reaction:

$$\text{phosphoenolypyruvate} + CO_2 \rightarrow \text{oxalacetate} + \text{orthophosphate} \quad (1)$$

In the presence of reduced diphosphopyridine nucleotide and malic dehydrogenase, the oxalacetate is reduced to malate;

$$\text{oxalacetate} + \text{DPNH} \rightarrow \text{malate} + \text{DPN} \quad (2)$$

The linked reaction,

$$\text{phosphoenolpyruvate} + CO_2 + \text{DPNH} \rightarrow \text{malate} + \text{DPN} + \text{orthophosphate} \quad (3)$$

may then be followed spectrophotometrically by measuring the decrease in absorption at 340μ caused by the oxidation of reduced diphosphopyridine nucleotide.

It has been suggested that phosphoenolpyruvate carboxylase may function in the synthetic accumulation of dicarboxylic acids in plant tissues and especially in those of the Crassulaceae[2,3]. This communication reports that the leaves of *Kalanchoë crenata* and two other Crassulacean plants contain this enzyme. Extracts of *Kalanchoë* leaves known to contain malic dehydrogenase brought about a rapid oxidation of reduced diphosphopyridine nucleotide in the presence of phosphoenolpyruvate and magnesium or manganese ions. Phosphoenolpyruvate could not be replaced by pyruvate and adenosine triphosphate. There was no appreciable decrease in absorption when reduced triphosphopyridine nucleotide was substituted for reduced diphosphopyridine nucleotide.

Pre-incubation of phosphoenolpyruvate with the leaf extract and magnesium ions caused increases in the initial rate of oxidation of added reduced diphosphopyridine nucleotide. A two-stage reaction is implied by the fact that, within limits, the initial rate of oxidation was directly related to the length of the pre-incubation period.

Production of malate during the course of the linked reaction (3) has been shown chromatographically and the hydrazone of oxalacetic acid prepared, and separated, from reaction mixtures containing no reduced diphosphopyridine nucleotide. Labelled malate and labelled oxalacetic hydrazone have been similarly prepared by adding radioactive bicarbonate to the appropriate reaction mixture. This is believed to be the first demonstration of malate synthesis *in vitro* catalysed by a cell-free preparation from a Crassulacean plant.

Bandurski[3] has reported a stimulation of phosphoenolpyruvic carboxylase by carbon dioxide. This has been confirmed by Brown[4] and by myself, who found a linear relationship between the reciprocals of reaction-rate and the reciprocals of (low) concentrations of both phosphoenolpyruvate and carbon dioxide. Between 0·1 and 10 per cent the rate of the linked reaction was affected only slightly, rising gradually below 0·5 per cent and then declining. Above 10 per cent this decline became pronounced, and the reaction was almost completely inhibited in 70 per cent carbon dioxide (that is, in a solution containing the bicarbonate calculated from the Henderson Hasselbach equation[5] to be in equilibrium

with an atmosphere containing 70 per cent carbon dioxide). As malic dehydrogenase was not depressed by carbon dioxide, it is presumed that reaction (1) was inhibited. There is a strong parallelism between this behaviour and the effect of carbon dioxide on dark acidification in the intact leaf[6]. This is consistent with the view that phosphoenolpyruvic carboxylase is the enzyme which actuates such acidification *in vivo*.

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[1] Bandurski, R. S., and Greiner, C. M., *J. Biol. Chem.*, **204**, 781 (1953).
[2] Tchen, T. T., and Vennesland, B., *J. Biol. Chem.*, **213**, 533 (1955).
[3] Bandurski, R., *J. Biol. Chem.*, **217**, 137 (1955).
[4] Brown, J. M. A., Ph.D. thesis, University of Durham (1956).
[5] Umbreit, W. W., Burris, R. H., and Stauffer, J. F., "Manometric Techniques and Tissue Metabolism", 25 (Minneapolis, 1949).
[6] Thomas, M., and Ranson, S. L., *New Phytol.*, **53**, 1 (1954).

Net Synthesis of Lecithin in an Isolated Enzyme System

Work in this Laboratory[1] has shown that the biosynthesis of lecithin and of phosphatidyl ethanolamine involves the intermediary formation of cytidine diphosphate choline and cytidine diphosphate ethanolamine. The enzymatic synthesis of lecithin is described in the following simplified scheme:

$$\text{Cyt-P-O-P-O-P} + \text{P-choline} \longleftrightarrow \text{Cyt-P-O-P-choline} + \text{P-O-P} \quad (1)$$

$$\text{Cyt-P-O-P-choline} + \text{D-}\alpha,\beta\text{-diglyceride} \longleftrightarrow \text{Lecithin} + \text{Cyt-P} \quad (2)$$

Previous experiments on the biosynthesis of lecithin in isolated enzyme systems have required the use of isotopic tracers, since the amounts of newly formed phospholipid were too small to be detected by conventional chemical methods. In such experiments, it was impossible to rule out the occurrence of reactions by which the labelled compound exchanges with the phospholipid in the enzyme preparation, bringing about an incorporation of the isotope without a net increase in phospholipid.

It has now been found that isolated mitochondria, incubated with cytidine diphosphate choline and D-α,β-diglyceride, catalyse the net synthesis of lecithin (Table 1). During the course of incubation with the complete system, the amount of phospholipid is almost doubled. Synthesis falls to a low level if the diglyceride is omitted, and no synthesis occurs if the cytidine diphosphate choline is omitted. It is necessary to carry out the reaction in the presence of small amounts of a surface-active agent such as 'Tween-20' (polyoxyethylene sorbitan monolaurate) in order that the diglyceride may penetrate to the site of enzymatic synthesis. There is good agreement when the synthesis as measured by the incorporation of radioactive choline from the cytidine diphosphate choline is compared with the net increase in lipid phosphorus.

Work in several laboratories[2] has led to the discovery in liver and brain of enzyme systems which rapidly synthesize phosphatidic acids. However, phosphatidic acids do not occur in appreciable concentrations in these tissues. Considerable speculation has therefore arisen as to the role of phosphatidic acids in the metabolism of lipids. It has now been found that mitochondria and microsomes from rat liver catalyse the reaction:

$$\text{Phosphatidic acid} \rightarrow \text{D-}\alpha,\beta\text{-diglyceride} + \text{inorganic phosphorus} \quad (3)$$

The dephosphorylation is inhibited by magnesium ions and 'Tween-20'. Therefore, if phosphatidic acid is added to enzyme systems such as shown in Table 1, which are synthesizing lecithin in the presence of magnesium ions and 'Tween-20', no stimulation of synthesis occurs. If the phosphatidic acid is pre-incubated with the enzyme, and then 'Tween-20', magnesium ion and labelled cytidine diphosphate choline are added, a stimulation of synthesis is observed (Fig. 1) which is proportional to the time

Table 1. The Net Synthesis of Lecithin in an Isolated Enzyme System

Additions	Lipid phosphorus (microatoms)	△ Lipid phosphorus (microatoms)	Total counts incorporated
1. None	1·19	—	—
2. Cytidine diphosphate choline	1·23	0·04	960
3. D-α,β-diglyceride	1·17	0	—
4. Cytidine diphosphate choline + D-α,β-diglyceride	2·25	1·06	13,375

Each tube contained 20 μmoles magnesium chloride, 10 μmoles cysteine, 40 μmoles tris(hydroxymethyl)aminomethane buffer of *p*H 7·4, 2 mgm. of 'Tween-20' and 8 mgm. of mitochondria from chicken liver in a final volume of 1 ml. Cytidine diphosphate choline (3 μmoles) labelled with choline-1,2-^{14}C (14,000 counts/μmole/min.) was added where indicated. D-α,β-diglyceride (4 μmoles), prepared from egg lecithin by the action of lecithinase from *Clostridium perfringens*, was also added to some tubes as shown. The tubes were incubated at 37° for 2 hr. The lipid fraction was isolated, counted and analysed for total phosphorus as described in ref. 4.

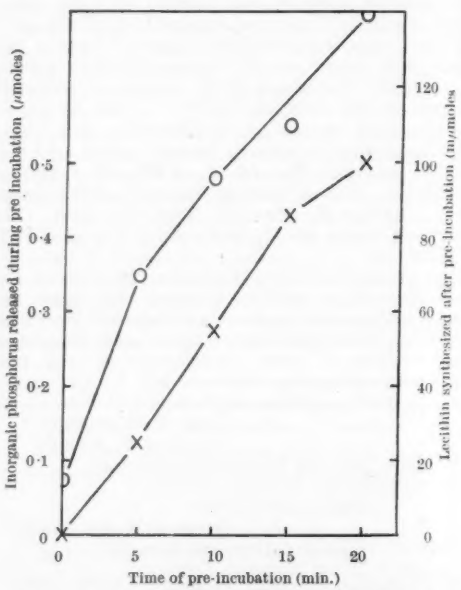

Fig. 1. 4·0 μmoles of phosphatidic acid were pre-incubated at 37° with 50 μmoles of tris(hydroxymethyl)aminomethane buffer of *p*H 7·4 and 2 mgm. of microsomes from rat liver for the time intervals shown. One set of tubes was then analysed for release of inorganic phosphate. To the other set, 5 mgm. of 'Tween-20', 20 μmoles of magnesium chloride and 1 μmole of cytidine diphosphate choline labelled with choline-1,2-^{14}C (56,000 counts/μmole/min.) were added and the incubation continued for another 2 hr. The release of inorganic phosphorus during pre-incubation (crosses) is plotted against the left-hand scale, and the synthesis of lecithin (circles) against the right-hand scale

of pre-incubation and to the prior release of inorganic orthophosphate.

These results indicate that phosphatidic acids may act as precursors of D-α,β-diglycerides *in vivo* and thus furnish the glyceride moiety of glycerophosphatides, and also show that the biosynthesis of phospholipids and neutral fats are intimately related processes.

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[1] Kennedy, E. P., and Weiss, S. B., *J. Amer. Chem. Soc.*, **77**, 250 (1955). Kennedy, E. P., and Weiss, S. B., *J. Biol. Chem.* (in the press). Kennedy, E. P., *J. Biol. Chem.* (in the press).

[2] Kennedy, E. P., *J. Biol. Chem.*, **201**, 399 (1953). Kornberg, A., and Pricer, jun., W. E., *J. Biol. Chem.*, **204**, 345 (1953). Dawson, R. M. C., *Biochim. Biophys. Acta*, **14**, 374 (1954).

Polynucleotide Phosphorylysis and Synthesis by Lysed Cells of *Micrococcus lysodeikticus*

AQUEOUS extracts of *Micrococcus lysodeikticus* possess a highly active enzyme capable of polymerizing mononucleotides reversibly[1]. In addition, the bacterial ribonucleic acid is readily phosphorylysed by this enzyme in the presence of inorganic phosphate. Because of these facts, we have attempted in a few preliminary experiments to evaluate the part this enzyme system may play in modifying the properties or content of bacterial cell ribonucleic acid during lysis of the cells and extraction procedures. In these experiments we have measured the acid-insoluble and acid-soluble fractions extractable from the cells during and after lysis in *tris* buffer, phosphate buffer, and in the presence of adenosine diphosphate in *tris* buffer, all experiments at *p*H 9·5. The cells were harvested from submerged 48-hr. cultures[2] and washed three times in 0·5 per cent sodium chloride. The concentration of cells was selected empirically by choosing a value which would, after complete lysis, yield an optical density of approximately 1·0 at 260 mμ for the acid-insoluble material when dissolved in 3 ml. of *tris* solution, *p*H 8·0, 0·1 *M*.

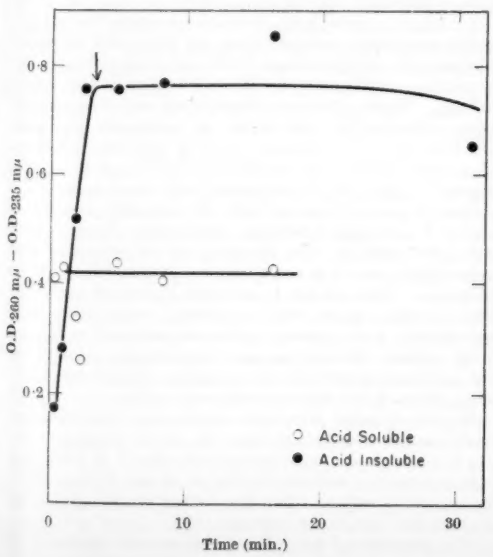

Fig. 1

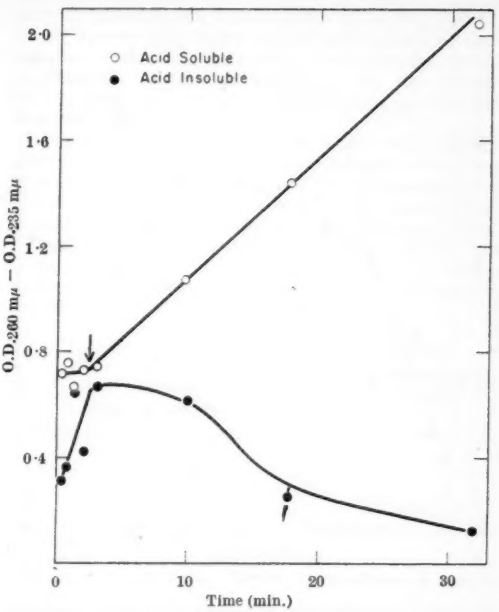

Fig. 2

In the first experiment (Fig. 1) 8 ml. of cells were mixed with 3 ml. of 0·1 *M tris* buffer and 5 ml. of 0·1 per cent lysozyme (Worthington crystalline enzyme). The suspension was incubated at 37°, and at periodic intervals 2 ml. aliquots were removed and added to 2 ml. of 5 per cent perchloric acid. The resulting precipitate and lysed cells were centrifuged down and the optical density of the supernatant measured at 235 mμ and 260 mμ. The sediment was washed once with 5 per cent perchloric acid, twice with 95 per cent ethanol, and finally dissolved in the *tris* buffer at *p*H 8·0. The optical densities were recorded as above. Plotted in Fig. 1 are the differences in optical densities at 235 mμ and 260 mμ, corrected for a 3-ml. sample. We observe that except for some scatter the acid-soluble fraction remains constant. The acid-insoluble fraction increases linearly until lysis is complete (vertical arrow), at which point this fraction, too, remains constant. The sensitivity of the method employed has not been developed to the point where we might detect transient changes in the acid-soluble fraction during the initial period of lysis. However, in view of the fact that the acid-soluble material is apparently easily extracted from intact cells, we do have a reliable indicator of any change in the concentration of the acid-soluble material should it occur. The linearity of the acid-insoluble curve suggests that the rate of lysis of the cells may be easily measured by this technique.

In the second experiment (Fig. 2) *tris* buffer was replaced by dipotassium phosphate. We observe

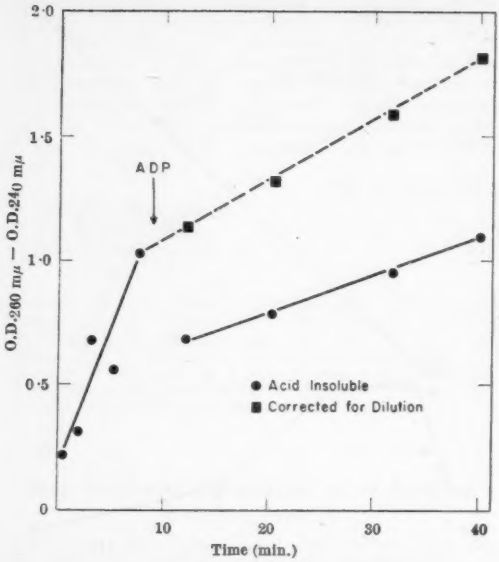

Fig. 3

the same initial increase in acid-insoluble material followed by a rapid drop. The acid-soluble material, after an initial lag, shows a remarkably linear increase. This experiment clearly demonstrates the phosphorylysis action of the lysed cells.

In the third experiment (Fig. 3) 4 ml. of cells were mixed with 2 ml. of ***tris*** buffer, 1 ml. of 6×10^{-3} *M* magnesium chloride, and 1 ml. of 0·1 per cent lysozyme. 1-ml. aliquots were removed, added to 2 ml. of 5 per cent perchloric acid and the acid-insoluble material was determined as above. In this instance the differences at 240 mμ and 260 mμ were recorded. After 10 min., lysis was complete. 2 ml. of 10^{-2} *M* adenosine diphosphate were added. Additional 1-ml. aliquots were removed and measured for acid-insoluble material. In Fig. 3 we observe first the rapid increase in acid-insoluble material followed by a drop after dilution with adenosine diphosphate and a linear increase thereafter. The rate corrected for dilution effects is also given. This experiment clearly demonstrates the polymerase action of the lysed cells. Indeed, the rate of synthesis by unfractionated lysed cells is sufficiently great to permit one to assay the cells for enzyme content using the previously described method of assay[1].

The relationship of these findings to the *in vivo* status of ribonucleic acid is not clearly defined by these experiments. We may state that possibly the ribonucleic acid of the intact cell exists in an equilibrium with the inorganic phosphate and diphosphate mononucleotides as it certainly does in the lysed cell. However, a very difficult practical problem is suggested by these findings. The presence of an easily displaced equilibrium in the lysed cells indicates a high turnover of ribonucleic acid and mononucleotides. In other words, although the amount of ribonucleic acid and mononucleotides as indicated in Fig. 1 may remain constant, the exchange between the mononucleotides and nucleic acid may be very large, particularly if the enzyme system is very active. Therefore, the specific structure of the ribonucleic acid may vary from moment to moment, the size of the nucleic acid molecules may decrease or increase, and, in general, the state of ribonucleic acid after lysis of the cell may bear no relationship to what actually exists in the cell. The remarks can also apply to ribonucleic acid isolated from other bacteria and yeast. We conclude, therefore, that such parameters as molecular weight, mononucleotide sequence, and *in vitro* determinations of amounts of ribonucleic acid extracted from bacteria and yeast can have no important biological significance unless one has carefully ruled out the role of polynucleotide phosphorylase in the procedures adopted for disrupting the cell walls and extracting the nucleic acid.

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[1] Beers, jun., R. F., *Nature*, 177, 790 (1956).
[2] Beers, jun., R. F., *Science*, 122, 1016 (1955).

Peroxide Formation in Bacteriological Media

It has been observed that small inocula of *Mycobacterium tuberculosis* grow poorly in synthetic media unless certain additions (serum fractions, hæmoglobin, cobalt, charcoal) all of which are peroxide-destroying agents are made. Highly isoniazid-resistant strains of *M. tuberculosis* (which are much more sensitive to hydrogen peroxide than isoniazid-sensitive strains) show a greater demand for such peroxide destroyers, especially when manganese is present in the medium[1]. Consequently, it has been suggested that these media contain traces of peroxide, although this had not been confirmed chemically.

We have examined Proskauer and Beck-type media and have shown that, as prepared in these laboratories, they contain 1–10 μgm./ml. of hydrogen peroxide. All the media investigated contained citrate. When citrate is autoclaved with manganese salts, substantial quantities of hydrogen peroxide are formed. For example, a 0·25 per cent solution of sodium citrate in phosphate buffer, *p*H 7, containing 1 μgm./ml. manganese (added as manganous chloride), autoclaved at 10 lb. for 10 min., contained about 7 μgm./ml. hydrogen peroxide. No peroxide was produced in the absence of manganese; but exceedingly small concentrations of manganese were effective. Thus about 1 μgm./ml. hydrogen peroxide was formed when 0·01 μgm./ml. manganese was autoclaved with citrate under the above conditions. Such traces of manganese were usually present in the asparagine used in these media, but occasionally were present in other constituents also.

No measurable peroxide production was observed from manganese and citrate at room temperature; at 37°, peroxide was formed slowly. A 0·25 per cent solution of sodium citrate produced 1·5 μgm./ml. hydrogen peroxide when incubated with 1 μgm./ml. manganese for three days at 37°.

The presence of peroxide was shown by liberation of iodine from potassium iodide, reaction with potassium

permanganate, oxidation of benzidine in the presence of peroxidase, luminescence with luminol, and formation of 'pertitanic acid' with titanic sulphate. The last method was usually employed for quantitative determination. We did not show for certain that the peroxide formed was hydrogen peroxide; but peroxide-destroying agents of widely different type and activity—hæmin, serum, cobaltous ions, cupric ions, ferrous and ferric iron, activated carbon, Adams catalyst, sodium hydrosulphite, reductone, pyruvic acid, ascorbic acid and cysteine—all removed this peroxide from media at the same rate as they removed added hydrogen peroxide.

Hydrogen peroxide is very stable in Proskauer and Beck-type media. In glycerol-buffer it is rapidly destroyed; but citrate or asparagine greatly reduces the rate of destruction, so that in the full medium hydrogen peroxide has a half-life of more than a month, when kept at room temperature.

It has been known for a long time that light can bring about the formation of peroxide in certain other bacteriological media[2,3]. Light is not necessary for its formation from citrate and manganese, however. The mechanism involved resembles rather the well-known phenomenon of 'autoxidation', by which certain substances in the presence of oxygen and water produce hydrogen peroxide. Classical examples are the oxidation of phosphorus, lead, zinc and turpentine, while there are references also to hydrogen peroxide production from isoniazid[4], hydrazine, ascorbic acid and some heterocyclic substances.

Peroxide formation thus appears to require a reducing system which will transfer hydrogen atoms (or electrons) to oxygen. With many reducing agents the peroxide formed would be further reduced to water. In some cases, however, this further reduction does not take place, or takes place more slowly than the peroxide is formed, so that peroxide accumulates. Citrate is not readily oxidized, and requires manganese as a catalyst and raised temperatures before it reduces oxygen to hydrogen peroxide.

A wide range of other reducing agents has been investigated for ability to produce peroxide when autoclaved in the presence of manganese. Although quite a number of substances produced very small traces of peroxide, only reducing sugars and some hydrazine derivatives gave levels comparable to those obtained with citrate. Some hydrazine derivatives were particularly strong peroxide formers with manganese at 37°—thus more than 200 μgm./ml. hydrogen peroxide could be obtained with isoniazid (conc. = 2 mgm./ml.).

The formation of peroxide from citrate appeared to be catalysed specifically by manganese. Silver, aluminium, arsenic, boron, barium, calcium, cobalt, chromium, copper, iron, mercury, magnesium, nickel, chromium, lead, tin and zinc under similar conditions failed to give measurable peroxide production when autoclaved with citrate. However, the possibility cannot be excluded that there are reducing systems with which metal ions other than manganese will function catalytically, leading to the formation of peroxide. Such reducing systems may be operative in the formation of hydrogen peroxide in types of media other than those which we have investigated. For example, cuprous salts (or metallic copper) will form traces of peroxide in the presence of water and oxygen—though this peroxide does not accumulate owing to the further action of copper salts in catalytically destroying hydrogen peroxide. But these traces may explain the results of O'Meara and Macsween[5] on the effect of small amounts of copper salts on the growth of a number of pathogens. It would appear that when copper was added to their peptone media, cuprous salts were formed during sterilization, which on exposure to air formed hydrogen peroxide, thus inhibiting the growth of the inocula.

It is interesting to note that Seigel and Galston[6] have shown that manganese stimulates the formation of peroxide in plant tissues, and have suggested that if the same phenomenon occurs in bacteria it may explain the mutagenic effect of manganese on them.

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[1] Cohn, M. L., Oda, U., Kovitz, C., and Middlebrook, G., *Amer. Rev. Tubere.*, **70**, 465 (1954).
[2] Richardson, A., *J. Chem. Soc.*, 1109 (1893).
[3] Dieudonne, A., *Arbeiten a.d. Kaiserl. Gesundheitsamte*, **9**, 405, 437 (1894).
[4] Winder, F., *Amer. Rev. Tubere.*, **73**, 779 (1956).
[5] O'Meara, R. A. Q., and Macsween, J. C., *J. Path. Bact.*, **44**, 225 (1937).
[6] Seigel, S. M., and Galston, A. W., *Arch. Biochem. Biophys.*, **54**, 102 (1955).

Nucleic Acid Turnover Studies in Human Leukæmic Cells and the Function of Lymphocytes

The experiments described here were undertaken to ascertain the pattern of purine utilization and turnover in the nucleic acids of different types of leukæmic leucocytes. The results indicate that leukæmic lymphocytes survive longer than leukæmic granulocytes. The results also direct attention to the possibility of re-utilization of large fragments of nucleic acids by lymphocytes, and invite speculation on the significance of this process as an explanation of the problem in long-term immunity of how formation of antibody continues long after the limited contact between tissues and antigen.

Adenine-8-carbon-14 (200 μc.) was given intravenously once to two patients having chronic lymphatic and to two having chronic granulocytic leukæmia; in the lymphatic leukæmia patients the predominant cell type was the small lymphocyte and in the granulocytic leukæmia patients the leucocytes were polymorphonuclears. Pentose nucleic acid and deoxyribose nucleic acid were isolated from leucocytes collected afterwards. In leucocytes from the first two patients the radioactivities of the separated individual purines were determined, and, for the other patients, the radioactivities of the pentose nucleic acid purine nucleotides and of the deoxyribose nucleic acid purines.

Representative data on the incorporation of adenine into deoxyribose nucleic acid purines of granulocytes and lymphocytes are shown in Fig. 1; for simplicity, data on pentose nucleic acid are not shown in the figure but will be described in the text.

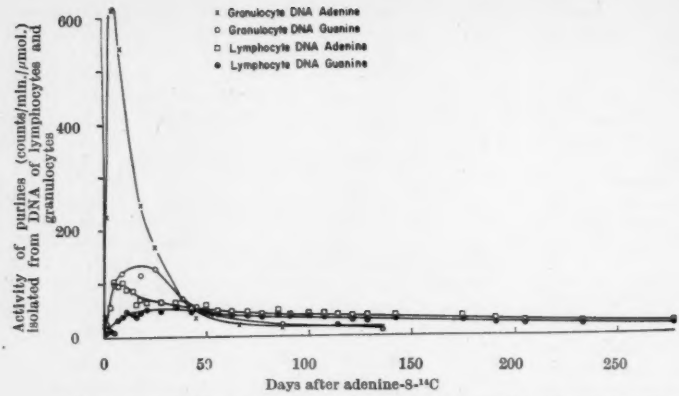

Fig. 1. Incorporation of adenine-8-^{14}C into DNA lymphocytes and granulocytes in chronic lymphatic and granulocytic leukæmia

In granulocytes, adenine as such was incorporated into deoxyribose nucleic acid; there was also extensive transformation of adenine into deoxyribose nucleic acid guanine. The curves of incorporation and transformation of adenine into polynucleotides of pentose nucleic acid and deoxyribose nucleic acid as a function of time were similar; as were also the retentions of isotope in the adenine and guanine of pentose nucleic acid and deoxyribose nucleic acid. A similarity of incorporation and turnover in pentose nucleic acid and deoxyribose nucleic acid of granulocytes is also found in intestine and bone-marrow—all of which are rapidly dividing tissues.

In lymphocytes, the incorporation of adenine into pentose nucleic acid and its transformation into pentose nucleic acid guanine resembled that in granulocytes (that is, the early portions of the curves were similar to granulocyte deoxyribose nucleic acid adenine and guanine); in contrast, the incorporation of adenine into deoxyribose nucleic acid and transformation of adenine into deoxyribose nucleic acid guanine were less extensive than the incorporation and transformation of adenine into pentose nucleic acid. In lymphocytes, then, contrary to much present belief, the lesser metabolic activity, as deduced from turnover data of deoxyribose nucleic acid compared with pentose nucleic acid, is characteristic of slowly dividing tissues such as liver.

In contrast to granulocytes, in which significant radioactivity was not demonstrated beyond 140 days, there was prolonged retention of isotope in both pentose nucleic acid and deoxyribose nucleic acid of lymphocytes; radioactivities in the deoxyribose nucleic acid purines gradually surpassed those in pentose nucleic acid. Although the initial portions of the pentose nucleic acid curves in lymphocytes were similar to the initial portions of the deoxyribose nucleic acid curves for granulocytes, in their later portions, as mentioned, they resembled the deoxyribose nucleic acid curves for lymphocytes.

The decline in activities of both pentose nucleic acid and deoxyribose nucleic acid purines of lymphocytes fell into two phases: an initial rapid decline, followed by a slow decline having a half-time of the order of 300 days.

The results suggest that the survival time of leukæmic granulocytes is less than that of leukæmic lymphocytes. If the assumption is made that deoxyribose nucleic acid once formed in a cell is stable for the life of that cell, analyses of the deoxyribose nucleic acid data permit calculations of the average survival time of each cell type (for example, by the solution of the Volterra integral equation of the first kind); this procedure is analogous to that used by Shemin and Rittenberg for the life-span of the red cell[1]. It was thus estimated that leukæmic granulocytes survive on the average for 23 days, and calculations based on the first part of the lymphocyte curves give an average survival time for leukæmic lymphocytes of 85 days. The present evidence does not permit decision whether the prolonged retention of isotope in the pentose nucleic acid and deoxyribose nucleic acid of lymphocytes (and not found in granulocytes) represents the survival of some cells for very long periods, or a specific re-utilization by lymphocytes of large fragments of nucleic acid or nucleoproteins of their progenitors.

Other kinds of evidence are in favour of the second interpretation. The phagocytosis of lymphocytes by reticulum cells in lymph nodes and the differentiation of these reticulum cells into new lymphocytes have been repeatedly observed[2]; cells have been described that are intermediate between these reticulum cells and large lymphocytes which still contain pyknotic fragments of lymphocyte nuclei (personal communications from Trowell, O. A., and from Dempsey, E. W.). Such observations suggest that there is re-utilization of large fragments of lymphocyte nucleic acids or nucleoproteins by phagocytosis.

Recognition that lymphatic tissue is an important site of protein synthesis—as indicated by antibody production—has been obscured by an inability to differentiate between the roles of lymph nodes and of the mature lymphocyte. The mature lymphocyte is little more than a nucleus, and this fact plus the re-utilization of lymphocytes by phagocytosis suggest that lymphocytes may function primarily as a store of deoxyribose nucleic acids. This hypothesis would afford an explanation of the ability to transfer immune reactions by the use of lymph nodes or lymphocytes[3]. Exposure of the embryo to antigens might result in the loss of specific deoxyribose nucleic acids responsible for the production of homologous antibodies, possibly by an absence of the conservation mechanism of phagocytosis and re-utilization in the embryo; the adult exposed as an embryo to an antigen would thus have lost the ability to respond[4]. Since antibodies are incapable of self-replication in later life[5], the process of phagocytosis with re-utilization of nucleic acids allows for the selective preservation of necessary templates for the production of specific antibodies, and might account for the continued formation of antibody long after the apparently limited contact between tissues and antigen. A fuller account of these studies will be published elsewhere[6].

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[1] Shemin, D., and Rittenberg, D., *J. Biol. Chem.*, **166**, 627 (1946).
[2] Heilberg, K. A., *Acta Med. Scand.*, **65**, 443 (1926–27). Bloom, W., "Handbook of Hematology", edit. Downey, **2**, 1429 (Hoeber, New York, 1938). Maximow, cited by Bloom, *ibid.*, 1488.
[3] Chase, M. W., *Proc. Soc. Exp. Biol. and Med.*, **59**, 134 (1945). Mitchison, N. A., *Nature*, **171**, 267 (1953).
[4] Billingham, R. E., Brent, L., and Medawar, P. B., *Nature*, **172**, 603 (1953).
[5] Heidelberger, M., Treffen, H. P., Schoenheimer, R., Ratner, S., and Rittenberg, D., *J. Biol. Chem.*, **144**, 555 (1942). Bulman, N., and Campbell, D. H., *Proc. Soc. Exp. Biol. and Med.*, **84**, 155 (1953).
[6] Hamilton, L. D., Henry Ford Hospital Symposium, "The Leukemias: Etiology and Pathophysiology" (Academic Press, New York, in the press).

Proteolytic Enzymes in *Entamoeba histolytica*

THE presence of proteolytic enzymes in *Entamoeba histolytica* has been suspected for many years and the extracellular secretion of these enzymes has been put forward by many authors as an explanation of the mechanism of tissue invasion by this parasite[1]. Experimental evidence of their occurrence in *E. histolytica* has been presented by several authors[2], though a detailed study of them has not been made.

The proteolytic enzymes of *E. histolytica* (strain $P + A^1$) were investigated by making an extract of amoebae grown *in vitro* in association with *Escherichia coli*. The amoebae were collected in suspension from the culture medium (solid egg base covered with dilute horse serum, supplemented with rice starch) and washed with Tyrode solution. The amoebae were re-suspended in a volume of Sørenson's phosphate buffer, *p*H 7·2, to give a calculated concentration of 5 million amoebae/ml. The amoebae were then frozen overnight. After thawing, the rice starch and debris were removed by centrifuging and the supernatant was shaken with a few drops of chloroform to inhibit the growth of bacteria. Excess chloroform was removed by centrifuging. Extracts prepared in this manner from strain $P + A^1$ were sterile.

The extract was incubated at 37° C. with casein solution as substrate and with ammonia – citric acid buffer to give a range of *p*H from 4·0 to 8·5. After incubation, the reaction was stopped by the addition of trichloracetic acid. The degree of hydrolysis of the casein was determined with Folin–Ciocalteau phenol reagent, and expressed as μgm./ml. of tyrosine. The method is similar to that described by Holter and Løvtrup[3].

The extract showed high activity from *p*H 6·5 to 8·5 with a maximum at *p*H 7·9–8·0. When the extract was incubated with the substrate at the optimum *p*H, the amount of hydrolysis increased linearly with time up to the end of 2 hr.; thereafter the rate of hydrolysis decreased. The activity was not potentiated by cysteine or inhibited by iodoacetate.

The proteolytic enzymes in extracts of strain $P + A^1$ also dissolved formalin-denatured gelatine and reduced the viscosity of gelatine solutions.

Extracts of the associated strain of bacteria, *Escherichia coli*, showed no proteolytic activity on the casein substrate, nor did they affect the viscosity of gelatine solutions.

Other strains of *E. histolytica* are being examined by this technique and all show some proteolytic activity. Further details of experiments showing the correlation of virulence and proteolytic activity will be published elsewhere.

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[1] Anderson, H. H., Bostock, W. L., and Johnstone, H. G., "Amebiasis" (C. C. Thomas, Illinois, 1953).
[2] Balamuth, W., and Thompson, P. E., "Comparative Studies on Amebae and Amebicides", in "Biochemistry and Physiology of Protozoa", **2**, edit. Hunter, S. H., and Lwoff, A. (Academic Press, New York, 1955).
[3] Holter, H., and Løvtrup, S., *C.R. Lab. Carlsberg, Chim.*, **27**, 27 (1949).

Disomic and Tetrasomic Inheritance in a *Solanum* Hybrid

IN the course of a cytogenetic study of the nature of differentiation of diploid species ($2n = 24$) of the section Tuberarium, genus *Solanum*, the mode of inheritance of three loci could be followed in a cross between *S. macolae* and *S. simplicifolium*, two species of the series Tuberosa occurring in Bolivia and Argentina. The *simplicifolium* parent used in the cross had simple leaves, a prominently winged stem and white corolla, in contrast to the compound leaves, rudimentary stem wing and purple corolla possessed by the *macolae* parent. Except for corolla colour in *macolae*, the two species bred true for their characters. The *macolae* parent was found to be heterozygous for *P*, a dominant factor necessary for the formation of purple colour in the corolla.

Meiosis was regular in the F_1 plants, and the plants set berries with viable seeds. These plants had compound leaves and prominently winged stems. There was segregation for corolla colour; six plants had purple and four plants had white corollas. In F_2 progenies from F_1 plants with compound leaves, prominent stem wing and purple corolla, there was monogenic segregation for all the characters. In backcrosses between the F_1 and recessive and dominant parents, 1 : 1 and ∞ : 0 segregations respectively were obtained. Thus, the genotypes of the *macolae* and *simplicifolium* parents were determined as *LLwwPp* and *llWWpp* (*L*, for compound leaf; *W*, for prominent stem wing and *P*, for purple corolla) respectively. There was no evidence of linkage among factors *L*, *P* and *W* in the F_2 and backcross data.

Seeds from the initial cross were treated with colchicine, and tetraploid hybrid plants were thus obtained. At first metaphase in the doubled hybrid, there was a mean frequency of 1·19 quadrivalents 0·095 trivalents, 21·025 bivalents and 0·905 univalents per cell. The number of quadrivalents per cell ranged from 0 to 4. The tetraploid plants were fertile. When the C_2, C_3 and C_4 plants (corresponding to the F_2, F_3 and F_4 plants of the diploid hybrid) were grown in following years, it was found that all

Table 1. Inheritance of Leaf-type in *S. macolae* × *S. simplicifolium*

Material	Genotype	Segregation				Deviation	
		Observed		Expected			
		L	*l*	*L*	*l*	X^2	*P*
F_2 progeny	*Ll* × *Ll*	45	16	5	1	0·0492	0·9–0·8
F_1 × *simplicifolium*	*Ll* × *ll*	52	44	1	1	0·6666	0·5–0·3
C_2 progeny	*LLll* × *LLll*	87	2	35	1	0·0920	0·8–0·7
C_2 progenies							
i. C_2 206 self	*Llll*	18	4	3	1	0·5454	0·5–0·3
ii. C_2 203 × 205	several possibilities	132	0	*X*	0		
iii. C_2 211 (compound) × C_2 198 (simple)	*LLll* × *llll*	73	19	5	1	1·0464	0·4–0·3
iv. C_2 198 self	*llll*	0	28	0	*X*		
C_4 progeny	*LLll*	39	1	35	1	0·0112	0·95–0·9

the plants in the different generations had broad stem wings like the C_1 and *simplicifolium* parents. Since the C_1 plants would have had the genotype *WWww* for stem wing character, the lack of segregation in subsequent generations would mean that the *simplicifolium* chromosomes carrying factor *W* were pairing preferentially at the tetraploid level. The segregation ratios for leaf type, however, were typical of tetrasomic inheritance; simplex and duplex genotypes were identified by the 3 : 1 and 35 : 1 ratios obtained on selfing C_2 plants (see Table 1) and a 5 : 1 ratio was observed on backcrossing a duplex to a nulliplex type. The chromosome numbers of the simple leaf plants in C_2, C_3 and C_4 were determined to make sure that the simple leaf character in them is not due to the loss of chromosomes carrying the *L* factor. The number in all the plants was $2n = 48$, and it is thus clear that the locus *L* in tetraploid *macolae* × *simplicifolium* segregates tetrasomically.

For colchicine treatment, seeds from the initial cross had been used, and consequently there was segregation for corolla colour in the C_1 plants (three coloured and two white). In the C_2 progeny grown from a sib-cross between two C_1 plants, one with coloured and another with white flowers, the forty-three plants which flowered all had coloured corollas. Two C_2 progenies were raised: one from seeds of a C_2 plant selfed and another from a C_2 sib-cross. Both segregated for corolla colour in the ratio 3 coloured : 1 white (observed: 29 : 11 and 12 : 5 respectively). The genotypes of the C_1 plants with purple and white corollas would be *PPpp* and *pppp* respectively, and the ratios suggest that the chromosomes in which the *P* locus is situated pair preferentially at the tetraploid level. From the data concerning the inheritance of factors *L*, *W* and *P* in the diploid and tetraploid populations of *macolae* × *simplicifolium*, it can be concluded that the quadrivalents and bivalents observed in the tetraploid are not formed in a random manner but result from pairing among specific chromosomes. These observations thus lend support to the inference drawn earlier from cytological studies[1] that cryptic structural differentiation of chromosomes has played an important part in the origin of species differences in the section Tuberarium.

This work was begun at the Laboratory of Genetics, Wageningen, Holland, in 1950, with material kindly supplied by Dr. H. J. Toxopeus, and was continued at the Plant Breeding Institute, Cambridge, and the Department of Genetics, University of Wisconsin. My thanks are due to Prof. R. Prakken, Dr. H. J. Toxopeus, Dr. H. W. Howard and Dr. R. W. Hougas for facilities and advice.

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[1] Swaminathan, M. S., and Howard, H. W., *Bibliographia Genetica*, **16**, 1 (1953).

Chelating Agents as Growth Substances

Since the article[1] under the above title was published, we have obtained further biological evidence bearing on the mode of action of auxin. We carried out two root-growth experiments exactly similar to those of 23.3.56 and 21.4.56 (Tables 4 and 5, *loc. cit.*) but using 8-hydroxyquinoline and ethylenediaminetetra-acetate instead of 3-indolylacetic acid and ethylenediaminetetra-acetate. Essentially similar results were obtained, that is, the inhibition of root growth caused by 10^{-5} *M* 8-hydroxyquinoline or 10^{-5} *M* ethylenediaminetetra-acetate alone was largely prevented by the presence of 10^{-11} *M* ethylenediaminetetra-acetate in the former case or of 10^{-11} *M* 8-hydroxyquinoline in the latter.

In a further similar root-growth experiment 2-hydroxyquinoline, a non-chelating analogue of 8-hydroxyquinoline, and ethylenediaminetetra-acetate were used. Again, a most remarkable interaction was obtained; but the roles of the two substances were no longer mutually interchangeable. Thus the inhibition due to 10^{-5} *M* ethylenediaminetetra-acetate alone was considerably less in presence of 10^{-11} *M* 2-hydroxyquinoline; but the rather small amount of inhibition caused by 10^{-5} *M* 2-hydroxyquinoline alone was made very much more severe by 10^{-11} *M* ethylenediaminetetra-acetate.

We have also extended the investigation of the growth responses of coleoptile sections to include supraoptimal concentrations of the agents, and so far the picture is essentially like that for inhibition of root growth in intact plants. Using concentrations of zero, 10^{-9}, 10^{-7}, 10^{-5} and 10^{-3} *M*, we have found with 3-indolylacetic acid and ethylenediaminetetra-acetate that a 10^{-9} *M* concentration of either agent greatly reduces or prevents the inhibitory or harmful effect of a 10^{-3} *M* concentration of the other. (At intermediate concentrations significant stimulation of course occurs, unlike the root-growth results.) The same type of mutual antagonism has been found in a similar experiment using 3-indolylacetic acid and 8-hydroxyquinoline and also in another using the latter and ethylenediaminetetra-acetate. With 2-hydroxyquinoline and ethylenediaminetetra-acetate the former shows only inhibitory effects; 10^{-9} *M* 2-hydroxyquinoline slightly increases the inhibition due to 10^{-3} *M* ethylenediaminetetra-acetate, whereas 10^{-9} *M* of this agent to some extent removes the harmful effect of 10^{-3} *M* 2-hydroxyquinoline. Here the roles of the two agents are reversed as compared with their effects on root growth (see above). With 2-hydroxyquinoline and 3-indolylacetic acid, the former again shows inhibitory effects throughout, but either agent at 10^{-9} *M* shows a small tendency to increase the inhibition due to a 10^{-3} *M* concentration of the other. (Two out of three root-growth experiments which were carried out using these two agents, at the usual concentrations of zero and 10^{-11} to 10^{-5} *M*, also showed no tendency

for a 10^{-11} M concentration of one to prevent the inhibition caused by a 10^{-5} M concentration of the other; the third experiment gave an aberrant result.)

The extraordinary mutual antagonism described has in fact always been found (and, with the exception of the single aberrant experiment mentioned, only been found) in experiments with two known chelating agents or with 3-indolylacetic acid and a known chelating agent; the substitution of a non-chelating analogue for one of the agents destroys the symmetry of the interaction or entirely prevents either agent at low concentration from reducing the inhibition caused by a high concentration of the other. The fact that 3-indolylacetic acid interacts with known chelating agents in the same remarkable and symmetrical way as these interact with each other in affecting the growth of roots and of coleoptile sections would seem strongly to support the hypothesis that it is here itself acting as a chelating or complex-forming agent. On this hypothesis, however, there is no reason why 3-indolylacetic acid should interact with the non-chelating 2-hydroxyquinoline in the same way as does ethylenediaminetetra-acetate if the latter interaction is not due to chelation.

Although the biological evidence for chelation or complex-formation by 3-indolylacetic acid appears to us convincing, we have not so far been successful in attempts to obtain direct chemical evidence. The difficulty experienced here may perhaps be due to 3-indolylacetic acid only forming complexes with one or a few metals and (or) within a narrow range of conditions; this might well be biologically advantageous to the plant.

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[1] Heath, O. V. S., and Clark, J. E., *Nature*, 177, 1118 (1956).

Effect of Desiccation on the Dormancy of Barley

In certain seasons the condition of dormancy in barley is prolonged and the delayed germination of a proportion of the grains has an adverse effect on its use for malting[1]. Observations over a number of years have indicated that this condition is more marked when atmospheric humidity is high before harvest. The effect of desiccation has therefore been investigated, as it is also an important factor in the maturation of wheat[2]. During ripening, transfer of material to the endosperm ceases at a moisture content of about 42 per cent, and the grain then undergoes rapid drying[3]. The final moisture content is determined, however, by the atmospheric humidity and the degree of desiccation therefore depends on the weather conditions before harvest.

Table 1. Effect of Desiccation on Percentage Germination, (*a*) During Ripening, and (*b*) at the Harvest-ripe Stage

	Moisture content (per cent fresh weight)	Percentage germination: After 10 days at 16°–18° C.	Percentage germination: After 3 days at 40° C. and 7 days at 16°–18° C.
(*a*)	40–45	6	95
	29–35	10	94
	16–20	44	96
(*b*)	17·4	44	99
	18·1	72	99
	16·9	82	100
	12·7	99	—

Table 2. Effect of Pre-drying after Harvest on the Percentage Germination

Treatment	No. of samples grouped according to percentage germination: 0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100
10 days at 16°–18° C. and 3 days at 40° C.	—	1	2	3	17	10	8	10	11	—
7 days at 16°–18° C.	—	—	—	—	—	—	—	1	4	57

The percentage germination was determined at intervals during the final stages of ripening by removing undamaged grains from the ear and placing them either directly in damp sterile sand, at 16°–18° C. for ten days, or after pre-drying for three days at 40° C., which reduced the moisture content to 7 per cent.

The effects of natural and artificial desiccation are shown in Table 1. About half the grains acquired ability to germinate as soon as the moisture content fell during ripening from 40 to 16 per cent, and the majority of the remainder did so later without any further desiccation. Complete germination did not, however, take place until atmospheric conditions allowed the moisture content to fall to 12·7 per cent, although it was obtained after pre-drying at each stage. Full maturity was thus eventually attained by natural desiccation, and although individual grains differed in their response to the same degree of desiccation at the harvest-ripe stage, these differences were removed by additional desiccation. There was no evidence that the dormant condition developed at the time of harvest, as suggested by Bishop[4].

When the dormant condition persists after harvest, it can also be successfully eliminated by additional desiccation. This is shown, in Table 2, by the increased germination after pre-drying obtained with sixty-two samples of commercial malting barley tested between August and October 1954.

It therefore appears that a varying proportion of grains may fail to reach maturity because of insufficient desiccation before harvest; but this can be corrected by artificial drying during subsequent storage.

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[1] Bishop, L. R., *J. Inst. Brew.*, **53**, 86 (1947).
[2] Wellington, P. S., *Ann. Bot.*, N.S., **20**, 105 (1956).
[3] Harlan, A. V., and Pope, M. N., *J. Agric. Res.*, **23**, 334 (1923).
[4] Bishop, L. R., *J. Inst. Brew.*, **50**, 166 (1944).

An Instance of Delayed Communication in Solitary Wasps

The eumenid *Rygchium foraminatum* (de Saussure) and the sphecid *Trypoxylon clavatum* Say are common solitary hunting wasps which nest in hollow twigs, making the burrows septate with cross-walls of mortar so that a linear chain of cells is formed. Each brood cell, when first made, contains a single egg along with paralysed prey sufficient for full growth of the young hatched larva to the adult wasp. Generally the provisioned cell is only somewhat larger than the wasp which will mature within it, and indeed may be too small in diameter to permit the adult wasp, once formed, to reverse its direction within it. The oldest wasp larva of necessity lies innermost at the blind end of the burrow, while the youngest occupies the cell nearest the sole exit from the nest. When

nests are constructed in burrows 4–6 mm. in diameter and 150 mm. long, each mother wasp may provision from 1–10 cells per burrow, most nests having 4–6 provisioned cells.

If a nest is split lengthwise after feeding, cocooning and pupation are completed, the pupæ which lie lengthwise in their cells are regularly found to face the sole exit of the nest. Orientation of a pupa toward the blind end of the burrow occurs, but is relatively rare and has serious consequences—especially in nests with minimal diameters. Ordinarily, emergence from linear nests is in reverse order to actual age, so that the wasp from the last egg to be laid is first to emerge from the nest, the next youngest wasp second to emerge, and so on. Misoriented wasps work their way, when they can do so, to the blind end of the burrow, generally resulting in the death of sibs older than themselves, and almost invariably in their own death as well. On the average, then, if misorientation is rare and random with respect to cell order, reversal of a single pupated wasp may be expected to result in the death of more than one nest occupant.

Since larvæ within their cells neither have nor can attain direct knowledge of the location of the exit from the burrow, and since larvæ may take any position within their cells during feeding, a highly efficient substitute for direct knowledge must be provided in the nest. Experiments have shown that the location of the egg, disposition of prey, possible asymmetric marking of the cell by the occipital glands of the mother, gaseous diffusion, and so on, at most play negligible parts so far as orientation of the larvæ at pupation is concerned. But if each cell's mud walls are reversed in position by rotation 180° about a diameter, care being taken to minimize breakage, then the enclosed larvæ pupate in reversed direction, that is, facing the blind end of the burrow.

The information acted upon by each pupating larva lies in the geometry and texture of the surfaces of the anterior and posterior cell walls. It can be shown that the information provided is redundant. A scanning comparison of two surfaces is not necessary to bias markedly the orientation of a pupating larva, nor indeed is a natural cell-wall necessary. A sandpaper disk placed transversely across a burrow, for example, is adequate to cause a larva to pupate facing the grit in the preponderance of cases. Furthermore, *Trypoxylon* larvæ, transferred to *Rygchium* nests, and vice versa, pupate with correct orientation toward the exit of the foreign nest. The informational signals of these remotely related wasps are thus similar.

The female wasp makes these cell walls asymmetric in relation to the nest's sole exit. In turn the larva responds to the asymmetry by orienting towards the nest's exit on entering the pupal state. In effect the mother wasp acts as an information source and transmitter, the mortar of the cell wall serves as a communication channel, and the geometry and texture of the walls as signals. The information is stored, then, in digital form in an artefact. The receiver and destination of the message is the fully fed larva, the highly regular response of which is in turn a measure of the singular effectiveness of the communication system.

Haldane and Spurway[1] and Haldane[2] have given analytical and interpretive summary accounts of animal communication that should do much to enliven research and discussion of this topic. The wasps discussed above provide a new and novel example of animal communication, for not only is the signal produced within a complete artefact, but also the stored signal serves as a message between parent and young, members of two generations that ordinarily do not overlap in contact. A detailed account of this work will be published elsewhere.

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July 2.

[1] Haldane, J. B. S., and Spurway, H., *Insectes Sociaux*, **1**, 247 (1954).
[2] Haldane, J. B. S., *Sci. Prog.*, **44**, 385 (1955).

Regenerative Capacity of Tadpoles inhibited in Growth and Development

As shown previously, 20-day old tadpoles of *Xenopus laevis* exhibit, after removal of the telencephalon and plexus chorioideus of the third ventricle, complete inhibition of development and almost complete cessation of growth[1]. In the course of recent experiments, we tested the regenerative capacity of these partially decerebrated experimental animals, operated on 2, 5 or 18 months before the amputation of the tail. As controls, we used tadpoles of the same length as the experimental ones. We were also able to compare regeneration in animals deprived of the telencephalon for two months with that of normal tadpoles of the same age, the development of which was delayed by the action of a lower temperature.

In spite of the inhibition of growth and development, the experimental animals retained the ability to regenerate amputated tail-tips. Whereas the first phases of the regenerative processes, that is, the covering of the wound surface with epithelial cells, proceeded at the same rate and in the same manner in experimental and in control animals, the visible regeneration of the axial organs appeared 2–3 days later in experimental tadpoles. The same result was obtained whether the tadpoles were operated on 2, 5 or even 18 months before the amputation of the tail.

In order to find out whether the inhibition of growth and development in experimental animals is in any way correlated with a decrease in mitotic activity, we determined the mitotic frequencies of the epithelial cells in mounted preparations of the tails. In every tail, we counted 6,000–10,000 cells in a series of fields, and expressed in percentages the number of dividing nuclei ranging from prophases to telophases.

In control animals, on the average, 1·3 per cent of mitotic nuclei were found, while two months after operation 0·4 per cent and 18 months after decerebration only 0·1 per cent mitotic nuclei were present. It seems, therefore, that the inhibition in growth observed in tadpoles after the excision of the telencephalon and plexus chorioideus on the twentieth day after hatching is due to a decrease in mitotic activity.

If, however, in inhibited tadpoles the tail tip is amputated and the regenerative processes set up, the number of dividing cells increases. Six days after amputation of the tail, we found 0·8 per cent of dividing nuclei in tadpoles decerebrated two months before amputation. A similar increase was observed in regenerating animals operated on five months before amputation. The increased number of dividing cells in regenerating experimental animals is probably induced by stimuli originating in wounded tissues

after the initiation of regenerative processes. We had previously found a similar effect in regenerating tadpoles treated with nitrogen mustard[2], and Lüscher described an increase in mitotic activity on the third to the sixth day after amputation of the tail of *Xenopus laevis* tadpoles[3].

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May 27.

[1] Jordan, M., *Fol. Biol.*, **3**, 331 (1955).
[2] Skowron, S., and Roguski, H., *Fol. Biol.*, **1**, 23 (1953).
[3] Lüscher, M., *Helv. Physiol. Pharmacolog. Acta*, **4**, 465 (1946).

Adrenaline and Noradrenaline in Adrenal Autografts

Both cortical and medullary cells survive in adrenal grafts months after transplantation into the anterior chamber of the eye[1]. It is, however, not known whether the two medullary hormones, adrenaline and noradrenaline, are present in the grafts. Moreover, all previous work has been without regard to the fact that there are two different types of cells in the adrenal medulla[2]. A substantial body of evidence is now available indicating that one of these cell types contains and secretes adrenaline, and the other noradrenaline[3,4]. It seemed therefore to be of interest to investigate adrenal grafts by chemical and histochemical methods which differentiate between adrenaline and noradrenaline.

Adult Wistar rats were used. The left adrenal of each animal was removed, and a piece of the medulla was inserted into the anterior chamber of the left eye. Five months later the animals were killed and the grafts removed.

The adrenaline and noradrenaline contents of some grafts were estimated chemically after separation of these amines by ascending paper chromatography, using a mixture of phenol and 0·1 *N* hydrochloric acid[4]. Both adrenaline and noradrenaline were detected in the grafts (Fig. 1). The adrenaline content was 5–10 times the noradrenaline content.

Other grafts were plunged into a 3·5 per cent solution of potassium dichromate to produce the chromaffin reaction, or into a saturated solution of potassium iodate to demonstrate the noradrenaline-containing cells[3]. These grafts were afterwards fixed in formalin and cut with a freezing microtome at 50μ. Some sections were mounted unstained in glycerol, others were stained with hæmatoxylin and sudan red to facilitate the detection of adrenocortical cells.

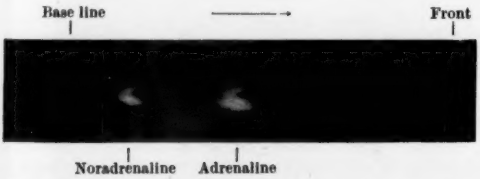

Fig. 1. Chromatogram of an adrenomedullary autograft smeared directly on the base line of the paper (Whatman No. 1). Phenol and hydrochloric acid were used for development, and the strip was sprayed with potassium ferricyanide to develop fluorescence in the adrenaline and noradrenaline spots. Fluorescence photograph

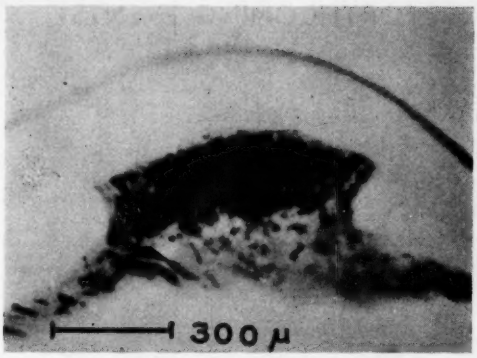

Fig. 2. Unstained frozen section of an adrenomedullary autograft in the anterior chamber of the eye. The graft is attached to the cornea (above) and the iris (below). Chromaffin cells are brown after dichromate fixation. Red blood cells in the vessels of the iris (lower left corner) are also brown

Fig. 2 shows a typical graft, mainly composed of strongly chromaffin cells, and attached to both the cornea and the iris. The chromaffin cells were closely packed together in the grafts. However, regular cell acini, such as can be always seen in the normal adrenal medulla, were replaced by irregular groups of cells. This may be indicative of cellular migration within the graft.

The iodate reaction, which stains the noradrenaline-containing cells brown[3,4], was positive in some graft cells, which were usually solitary and randomly distributed in the graft. The majority of graft cells, although chromaffin, remained colourless after iodate treatment. This is in good agreement with the chemical observations made, and suggests that the grafted adrenomedullary cells have retained their ability to make and secrete the same catechol amine which they were making and secreting in the adrenal before grafting.

Although efforts had been made to include only medullary tissue in the grafts, typical sudan-positive cortical cells were detected in all grafts which were examined histologically. The cortical cells were fewer than the medullary ones and usually apart from these. It is therefore most likely that cortical hormones were equally available to both the iodate-positive, noradrenaline-secreting cells and the adrenaline-secreting cells of the graft, in which the two types of cells were present in proportions similar to those in the normal rat's adrenal medulla. If cortical hormones really have a specific influence on the quality of the secretory products of the adrenomedullary cells, as has been claimed[5], such an influence could not be observed in the present study.

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May 25.

[1] Turner, C. D., Haffen, R., and St. Amant, L., *Proc. Soc. Exp. Biol. Med.*, **41**, 474 (1939). Coupland, R. E., *Nature*, **175**, 211 (1955).
[2] Eränkö, O., *Nature*, **168**, 250 (1951). *Acta Anat.*, **16**, Supp. 17 (1952). Hillarp, N. Å., and Hökfelt, B., *Acta Physiol. Scand.*, **30**, 55 (1953). Picard, D., and Vitry, G., *C.R. Soc. Biol.*, **148**, 556 (1954).
[3] Hillarp, N. Å., and Hökfelt, B., *Endocrinol.*, **55**, 255 (1954); *J. Histochem. Cytochem.*, **3**, 1 (1955).
[4] Eränkö, O., *Ann. Med. Exp. Biol. Fenniæ*, **32**, 392 (1954); **3**, 3, 278 (1955); *Nature*, **175**, 88 (1955); *Endocrinol.*, **57**, 363 (1955).
[5] Shepherd, D. M., and West, G. B., *Brit. J. Pharmacol.*, **6**, 665 (1951). Coupland, R. E., *J. Endocrinol.*, **9**, 194 (1953). Wright, A., and Chester Jones, I., *Nature*, **175**, 1001 (1955).

FORTHCOMING EVENTS

Wednesday, September 19

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. W. T. Lyn: "Diesel Combustion Study by Infra-Red Emission Spectroscopy".

Thursday, September 20

Oil and Colour Chemists' Association (at University College, Gower Street, London, W.C.1), at 10.30 a.m.—Symposium on "Some Implications of Colour".

Physical Society (in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Prof. J. G. Daunt (Ohio State University): "The Magnetic Refrigerator for Temperatures below 1° K." (Duddell Lecture).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Chemist (with a first- or good second-class honours degree in chemistry, or equivalent qualification, at least three years experience, and preferably a knowledge of liquid fuels and lubricants), at the London Transport Central Laboratory, Chiswick, London—The Recruitment and Training Officer, London Transport, 55 Broadway, London, S.W.1, quoting F/EV.597 (September 20).

Lecturer in Applied Mathematics—The Registrar, The University, Liverpool (September 20).

Senior Lecturer (with high academic and research qualifications) in Organic Chemistry, and a Lecturer (able to teach their branch of chemistry to special (honours) degree standard) in Inorganic and Physical Chemistry—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (September 21).

Assistants (3), Grade B (for physics, general chemistry and mathematics), in the Science Department, Birkenhead Technical College—The Director of Education, 63 Hamilton Square, Birkenhead (September 22).

Lecturer and Assistant Lecturer in Physics at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 29).

Lecturer or Assistant Lecturer (with special interests in general, inorganic or physical chemistry) in Chemistry—The Registrar, The University, Sheffield (September 29).

Lecturer, Grade II, in Physiology at the University College, Ibadan—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (September 29).

Federal Information Officer (with considerable experience of information service work, preferably in the Caribbean area), to plan and build up the Information Service of the Federal Government and to serve as Executive Head of the service stationed initially in Barbados—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.148/500/01 (September 30).

Lecturer (with a good degree in economics, commerce, administration or some branch of technology, with managerial experience in industry and preferably with some research experience in any of the above fields) in Industrial Administration, to deal with management subjects from a general management viewpoint and to undertake research—The Registrar, College of Science and Technology, Manchester 1 (September 30).

Junior Research Fellow, Research Fellow and Senior Research Fellow (with a good honours degree in economics and an interest in economic analysis) for the Research Staff of the Institute of Social and Economic Research, University College, West Indies, for investigations which may be made in any part of the British Caribbean territories—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 1).

Lecturer or Assistant Lecturer (with a good degree in science or applied science, and research experience in general ceramics, refractory materials or related fields, preferably with some industrial experience) in Ceramics and Refractory Materials—The Registrar, The University, Leeds 2 (October 1).

Statistician (with an honours degree in economics or commerce, able to give close attention to detail and to write clearly) in the Area Statistician's Office, Eastern Gas Board, Tottenham, London, for work concerned partly with the compilation of statistics and partly with the preparation of statistical reports for the guidance of the management—The Secretary, Eastern Gas Board, 2 The Abbey Garden, Great College Street, Westminster, London, S.W.1 (October 6).

Senior Lecturer in Aeronautical Engineering at the University of Sydney, to work in the field of aerodynamics—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 8).

Senior Lecturer or Lecturer in Physical Chemistry or Inorganic Chemistry at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 12).

Lecturer in Botany at the University of Natal—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

Lecturer or Assistant Lecturer (graduate, with experience and/or special interest in surveying and tutorial mapwork) in Geography at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 15).

Lecturer or Senior Lecturer (with qualifications in economic geography) in Geography at the Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 15).

Lecturer (graduate in chemistry with a knowledge of modern synthetic resins and rubbers) in the Department of Leather Industries, to give instruction in, and to investigate the application of synthetic resins and rubbers to various leathers—The Registrar, The University, Leeds 2 (October 15).

Director of the Computing Unit—The Secretary of Faculties, University Registry, Oxford (October 30).

Lecturer or Senior Lecturer in Fluid Dynamics at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 31).

Assistant Conservators (with a university degree in forestry) of Forests in British Guiana—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/30/02.

Cyclotron Engineer or Physicist (graduate in light electrical engineering or physics) at Hammersmith Hospital, to work on the cyclotron, with opportunity to gain experience in engineering mechanics including cyclotron beam measurements, high vacuum work, target design and ion sources development—The Senior Cyclotron Engineer, Medical Research Council, Hammersmith Hospital, Ducane Road, London, W.12.

Fisheries Officer (with an honours degree in natural science with emphasis on zoology, preferably with a knowledge of French and experience of work at sea and the handling of nets) for the Western Region of Nigeria, to develop inshore fishing and fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.461/410/03.

Geologist (with a first- or second-class, upper division, honours degree in geology, preferably with experience in an alluvial diamond field) with the Government of Sierra Leone, for the geological examination and mapping of the diamond deposits of Sierra Leone, together with special reference to the areas now being opened up under the Diamond Licensed Mining Scheme, to describe these areas and to prepare a report and eventually a bulletin on these deposits—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/15/01.

Graduate in Biological Science in the Department of Zoology, to assist in research on mass culture of marine algae—Professor of Zoology, The University, Southampton.

Health Physicist (with a degree in physics and some experience in nuclear physics and electronics, and an interest in biophysics, physiology or biology, preferably with a knowledge of French) with the European Organization for Nuclear Research, Geneva, to take charge of a small team entrusted with the physics measurements pertaining to all radiation protection in all CERN laboratories, and to develop measuring techniques in an unusually high energy region (up to 600 MeV. protons)—The Ministry of Labour and National Service, Employment Services Department (AS.12), 26 King Street, London, S.W.1.

Junior Scientific Officer (with an honours degree in science, pharmacy or biology), for technical work in the Blood Transfusion Service Laboratories—The Director, Blood Transfusion Service, Roby Street, Manchester 1.

Scientific Officers (3) (with first- or second-class honours degrees in civil engineering, economics or statistics, or equivalent qualification) in the Colonial Section, Road Research Laboratory, Department of Scientific and Industrial Research, for duties concerning road materials and methods of construction, soil mechanics, traffic engineering, road safety and economics of roads and road transport—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting E.384/6A.

Technician (with a good knowledge of electronics and experience in the construction and maintenance of electronic apparatus) in the Department of Applied Electrophysiology—The Secretary, The National Hospitals for Nervous Diseases, Queen Square, London, W.C.1.

Training Officer (with an engineering or science degree and training and organizing experience) in the Public Works Department, Government of Western Nigeria, to be responsible for training junior grades of a large Government Department and to correlate training facilities to ensure the fullest use is made of existing educational and technical establishments—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/410/018/T.

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